Analysis of Brain Waves Before and After Plant Cutting Procedure

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ABSTRACT

The purpose of this study was to analyze brain waves before and after the plant cutting procedure in 34 adult subjects. After plant cutting procedure, RT(Relative power of theta) decreased and RB(Relative power of beta), RMB(Relative power of mid beta), RHB(Relative power of high beta), RST(Ratio of SMR to theta spectrum), RMT(Ratio of mid beta to theta), and RSMT(Ratio of SMR~mid beta to theta) increased, while RA(Relative power of alpha), RLB(Relative power of low beta), and RG(Relative power of gamma) did not change significantly. The decrease in the RT indicator means that the cutting did not cause anxiety as a stable work rather than a high level task. Therefore, it is considered that the cutting activity can be applied to the subjects with low cognitive level such as children, dementia, and intellectual disabilities and those who should avoid the psychological burden due to the performance of the work. The increases in RB, RMB, and RHB indicators mean a state of mental awakening, inducing concentration similar to meditation. Therefore, the activity of cutting can be applied to people who use psychological energy in daily life, psychological confusion, excessive unnecessary thought, troublesome problems. The increases in the RST, RMT, and RSMT indicators mean an increase in concentration. Therefore, it is possible to apply the cutting activity for the purpose of strengthening the attention and intensifying induction. The results of this study are meaningful that it was confirmed that the cutting activity could induce the brain to be awakened by inducing concentration through conscious activities without giving an intellectual anxiety or psychological burden.

Keywords: α wave, activation of EEG, horticultural activity, plant cutting

Introduction

According to the overload and arousal theory of Ulrich and Parsons (1992), surrounding environments in the modern society such as noise, movement and visual complexity constantly overwhelm human senses, and cause psychological and physiological excitement. Meanwhile, environments surrounded by plants are less complex, have patterns that reduce arousal, and thus reduce stress (Simson and Straus, 1998). For this reason, plants have been often used as a medium for healing recently.

‘Horticultural therapy’ is one of the most popularly used services utilizing plants. Horticultural therapy was searched as

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a keyword in the Research Information Service System (RISS), and it was found that a total of 281 studies were registered in South Korea for the past 5 years (2014~2018). They include 231 experimental studies, 32 research studies and 18 other studies such as those on developing programs. Out of the 231 experimental studies, 221 studies used questionnaires, and the rest 10 studies used physiological indicators such as blood test, pinch test and three-dimensional motion analysis. Studies on the effects of horticultural therapy programs have been actively conducted, but there are little studies using physiological indicators. The physiological indicators used in earlier studies include cortisol and serotonin using a blood test (Lee et al., 2017a), the muscular strength of the fingers using a pinch test (Kim, 2015), blood pressure, pulse (Yun, 2007), etc. These studies are still about the effects of horticultural therapy programs that provide a series of sessions of horticultural activities. In order to identify the effects of horticultural activities on humans, it is necessary to analyze the effects of individual activities that compose a program, and these analysis results can be actively utilized to select horticultural activities suitable for subjects in performing horticultural therapy (Lee et al., 2017b).

Against this backdrop, this study aimed to analyze the brain waves of subjects before and after participating in activities of cutting plants as a follow-up study of Lee et al. (2017b) on the analysis of changes in brain waves before and after sowing seeds, to identify the effects of activities of cutting plants, and to support the selection of target subjects.

Methods

Subjects

This study was conducted among 36 right-handed adults in their 20s to 60s who had an experience of participating in horticultural activities, and the data of a total of 34 adults (27 females and 7 males), except those whose data have errors were analyzed. They were recruited through an announcement of the National Institute of Horticultural and Herbal Science. Those who voluntarily consented to participate in this study were informed of the purpose and process of this study, and signed a consent form, which was copied. One was given to the subject and the other was kept by the researcher of this study. The average age of the subjects was 41.32 ± 14.59 years, and their average height and weight were 163.47 ± 8.11 cm and 62.85 ± 12.91 kg respectively.

Laboratory Preparation

This experiment was carried out in a windowless laboratory (length: 320cm, width: 250cm, height: 265cm) located in the National Institute of Horticultural and Herbal Science (Lee et al., 2017b). A white table (length: 100cm, width: 50cm, height: 60cm) and a high-backed chair were placed in the laboratory. An analysis sheet on the process of cutting plants was attached on the wall 150cm in front of the subject for him or her to refer to. The average temperature, humidity, noise and illuminance of the laboratory was $24.86 \pm 0.70^\circ\text{C}$, $48.62 \pm 12.85\%$, 48.59 ± 1.82 db, and 33.956 ± 20.99 lux respectively.

Worktable Preparation

A stainless ball (diameter: 26cm, height: 10cm, weight: 255g) was placed in the lower right area of the center of the worktable, and a pair of scissors (length: 20cm, weight: 65g) was placed on the right side of the stainless ball. A watering can that contained 60ml of water (diameter: 11cm, height: 13cm, total weight: 261g) was placed right above the scissors, and a zipper bag that contained 300ml of bed soil used for horticultural purposes (width: 16cm, length: 17cm, total weight: 70g) was placed on the left side of the watering can. A beaker that contained 40ml of water (diameter: 6.5cm, height: 7cm, total weight: 56g) was placed on the left side of the zipper bag, and a black-colored plastic trowel (length: 26cm, width:

7cm, weight: 52g) was placed on the left side of the beaker. A 3-hole empty plug tray (width: 15.5cm, length: 5cm, height: 5cm, weight: 7g) was placed on the left side of the trowel, and a pot of *Chrysanthemum* (total height: 20-25cm) was placed on the left side of the tray. A white label (width: 4.5cm, length: 7cm, weight: 1g) was placed on the left side of the pot, and a black name pen (length: 13.5cm, weight: 8g) was placed on the left side of the white label (Figure 1).

Subject Preparation

The characteristics of normal brain waves differ depending on the conditions of the body such as sleeping, arousal and sleepiness (Korean Society of EEG Research, 2017). For this reason, Kim et al. (2017) suggests the following guidelines for obtaining quality EEG data. Subjects are instructed not to drink alcohol but to get enough sleep on the day prior to measuring EEG. They are ensured to refrain from consuming caffeine and nicotine, and they are also instructed to wash their hair but not to apply hair care products over the hair on the day prior to the experiment.

In this study, the subjects were instructed to get enough sleep and not to drink alcohol on the day prior to this experiment, and not to drink coffee or stimulants (energy drinks) for one hour prior to this experiment. They were also instructed not to excessively exercise before participating in this experiment. In addition, the subjects were instructed, if possible, to wash and dry their hair before coming to the laboratory in order to collect electrical signals transmitted from the scalp more efficiently. They were also instructed to fully understand the process of cutting plants. After arriving at the laboratory on the day of the experiment, they took a rest for over 10 minutes. The researcher of this study informed the subjects of the purpose and process of this study, and the subjects read the overview of this experiment and read and signed the consent form for this experiment. After that, they changed into a laboratory gown in a changing room, and electrodes were attached on the head of the subjects in the laboratory.

Attachment of Electrodes and Measurement of Brain Waves

To analyze the brain waves of the subjects, electroencephalogram (EEG) in which electrical changes in the brain are measured by putting a cap attached with electrodes on the head was adopted. Brain waves are changes in an electrical current caused by the flow of ions within neurons in the brain, and electroencephalogram (EEG) is defined as the flow of the

Figure 1. Table setting for plant cutting procedure.

electrical current and an act of measuring the flow (Niedermeyer and Lopes da Silva, 2005). EEG signals were measured using BIOS24 (Biobrain inc., Daejeon, Korea), a 24-channel wired polygraph system. The measured analog signals were sampled at 250Hz into digital signals, and were sent via USB to a personal computer. The transmitted digital EEG signals were filtered using an EEG analysis program called BioScan (Biobrain inc., Daejeon, Korea). EEG rhythms were analyzed by frequency range, and spectrum values were calculated by reflecting the quantitative amount of EEG rhythms.

In this experiment, Relative power of theta(RT), Relative power of alpha(RA), Relative power of beta(RB), Relative power of low beta(RLB), Relative power of mid beta(RMB), Relative power of high beta(RHB), Relative power of gamma(RG), Ratio of SMR to theta(RST), Ratio of mid beta to theta(RMT) and Ratio of SMR~mid beta to theta(RSMT) were analyzed.

RT (relative power of theta) is the relative power spectrum value obtained by dividing the theta wave (4-8 Hz) by the entire frequency range (4-50 Hz), and is known to increase more when thinking creatively and scientifically or solving problems in an intelligent test than in a stable state (Kim and Chang, 2001; Kwon, et al., 2006). RA (relative power of alpha) is the relative power spectrum value obtained by dividing the alpha wave (8-13 Hz) by the entire frequency range (4-50 Hz), and is known to increase when the brain function is relaxed and stable, and to decrease when solving complicated and difficult tasks (Yeon, 2013). RB (relative power of beta) is the relative power spectrum value obtained by dividing the beta wave (13-30 Hz) by the entire frequency range (4-50 Hz), and is known to increase more mainly in the parietal lobe in a state of arousal or when doing conscious acts than in a stable state (Yeon, 2013). RLB (relative power of low beta) is the relative power spectrum value obtained by dividing the low beta wave (12-15 Hz) by the entire frequency range (4-50 Hz), and is known to increase in the process of cognition or when highly concentrating on something (Jo, 2014). RMB (relative power of mid beta) is the relative power spectrum value obtained by dividing the mid beta wave (15-20 Hz) by the entire frequency range (4-50 Hz), and is known to increase when feeling sleepy or meditating. It is also known that the higher the value, the higher the concentration level (Lee, 2011). RHB (relative power of high beta) is the relative power spectrum value obtained by dividing the high beta wave (20-30 Hz) by the entire frequency range (4-50 Hz), and is known to increase under severe stress or in an excited state (Jo, 2014). RG (relative power of gamma) is the relative power spectrum value obtained by dividing the gamma wave (30-50 Hz) by the entire frequency range (4-50 Hz), and is known to increase under visual stimulation or in an emotionally nervous state, or when doing cognitive activities such as inference and judgement (Yeon, 2013; Jo, 2014). RST (ratio of SMR to theta spectrum) is the spectrum value obtained by dividing the SMR (Sensorimotor rhythm) wave (12-15 Hz) by the theta wave (4-8Hz), and is known to occur when attention reaches its peak (T.H. Kim, 2018). RMT (ratio of mid beta to theta) is the ratio of the mid beta wave to the theta wave in the entire frequency range, and is known to involve in attention and concentration. The higher the RMT value, the higher the concentration level (Lee, 2011; Yeon, 2013). RSMT (ratio of SMR~mid beta to theta) is the spectrum value obtained by dividing the SMR~mid beta wave range (12-20 Hz) by the theta wave (4-8 Hz), and the higher the RSMT value, the higher the concentration level (Jo, 2014; Lee, 2011; Yeon, 2013).

To measure the reference value for a EEG electrode cap and EEG signals before measuring EEG, the reference electrode was attached on the earlobe like a clip, and according to the International 10-20 system, a total of 21 electrodes were placed (Figure 2). In this experiment, two electrodes (Fpz and Oz) in the area where electrodes are concentrated were excluded, and the data of a total of 19 electrodes were collected. The data of C3, CZ and C4 located in the middle part of the brain were also collected, but they were excluded as they are located in the boundary area between the frontal lobe and the parietal lobe.

The EEG of the subjects was measured in a relaxed state in a seated position with the eyes closed for one minute before starting the activity of cutting and for one minute after finishing the activity (Figure 3).

Electrode arrangement diagram	Electrode site	Brain lobe
Fp1	Prefrontal lobe
	Fp2	
	F3	Frontal lobe
	F4	
	F7	
	F8	
	Fz	
	T3	Temporal lobe
	T4	
	T5	
	T6	
	P3	Parietal lobe
	P4	
	Pz	
	O1	Occipital lobe
	O2	

Figure 2. Electrode cap arrangement diagram and brain lobe.

EEG	
Electrode cap	Reference
Head	Right earlobe

Figure 3. Electrode equipment and position for EEG measurement.

Composition of Activities of Cutting Plants

The process of cutting plants was composed of a total of 5 stages including mixing soil; filling soil; cutting plants; writing labels; and watering (Table 1). According to the instructions given by the researcher, the subjects performed the activities by referring to the analysis sheet on the entire process attached on the wall in front of them. This experiment had been performed from August to November, 2017.

Data Processing and Statistical Analysis Methods

To analyze EEG data, the data were processed using the following statistical analysis methods. The average value and

Table 1. Plant cutting process

	Step	Contents	
1. Mixing soil	1	Bring the stainless bowl to the center of your body	
	2	Break up and loose hard soil with scissors	
	3	Pour all the soil into the stainless bowl	
	4	Pour all the water in a plastic beaker into the stainless bowl	
	5	Mix water and soil evenly by hand	
	6	Dust off your hands	
	7	Push the stainless bowl slightly to the right	
2. Filling soil	8	Bring the plastic pot tray to the center of the body	
	9	Hold a garden shovel with your right hand	
	10	Fill the tray with soil using a garden shovel	
	11	Flatten the top of the plastic pot tray.	
	12	Dust off your hands	
3. Cutting	13	Bring the flower pot (chrysanthemum) to the center of the body	
	14	Hold your scissors with your right hand	
	15	From the plant (chrysanthemum), take a stem of a plant with your left hand	
	16	Cut the 5th to 6th sections from the top of the selected stem with scissors	
	17	Put down the scissors	Repeat 3 times
	18	Remove the two leaves from the bottom of the cutting with your right hand	
	19	Move the stem (chrysanthemum) with your right hand and insert it deep into the center of one cell of the tray	
4. Writing labels	30	Write the name of the plant (chrysanthemum) and date on the label	
	31	Place the label on the front edge of the tray	
5. Watering	32	Hold the pot tray with your right hand	
	33	Gives all the water to the tray	
	34	Put down the tray	
6. Wrap-up	35	Rest your hand on the table	

standard deviation of the brain wave indicators (RT, RST, RMT, RSMT) before and after performing the activities by the area of the brain (prefrontal lobe, frontal lobe, temporal lobe, occipital lobe) were analyzed using descriptive statistics. Differences in EEG between before and after performing the activities by the area of the brain were statistically tested using SPSS Win Ver. 22.0, a statistical analysis program. The number of subjects whose data were analyzed in this study was 34. When a group composed of 30 subjects or more is in general recognized as a normally distributed group (Bae, 2012), and thus a paired T test was performed. The significance level was .05.

Results and Discussion

The average time consumed for performing the activities of cutting plants was 268 ± 66 seconds.

Changes in RT Before and After Performing the Activities

RT before and after performing the activities of cutting plants was analyzed, and RT in F4 ($p=.034$) and O1 ($p=.033$)

Table 2. Changes in Relative power of theta (RT) waves before and after plant cutting work

Brain lobe	Site	M±SD (μV2)		t	p
		Before	After		
Prefrontal lobe	Fp1 ^z	0.404±0.147	0.384±0.163	0.757	.454
	Fp2	0.404±0.143	0.378±0.160	1.166	.252
Frontal lobe	F3	0.379±0.152	0.359±0.174	0.872	.389
	F4	0.404±0.145	0.368±0.164	2.215	.034*
	F7	0.421±0.126	0.405±0.141	0.841	.406
	F8	0.412±0.130	0.393±0.159	0.846	.403
	Fz	0.406±0.142	0.372±0.168	1.893	.067
	T3	0.380±0.151	0.359±0.177	0.872	.389
Temporal lobe	T4	0.394±0.148	0.362±0.174	1.289	.206
	T5	0.361±0.162	0.329±0.184	1.507	.141
	T6	0.365±0.156	0.350±0.186	0.639	.527
	P3	0.374±0.157	0.349±0.173	0.967	.340
Parietal lobe	P4	0.353±0.157	0.335±0.185	0.814	.422
	Pz	0.352±0.164	0.318±0.184	1.302	.202
	O1	0.371±0.148	0.319±0.185	2.227	.033*
Occipital lobe	O2	0.376±0.153	0.347±0.186	1.239	.224

^zSee Figure 2 for the detailed position.*Significant at $p < .05$ level by paired t-test.

statistically significantly decreased after performing the activities compared to the value before performing the activities. RT in the rest areas also tended to decrease, but there was no statistically significant difference (Table 2).

RT (relative power of theta) tends to increase more when thinking creatively and scientifically or solving problems in an intelligent test than in a stable state, and tends to increase, in particular, when the level of tasks to be solved is high (Kim and Chang, 2001; Kwon et al., 2006). In the case of adults, RT increases in an emotionally nervous state caused by frustrated experiences and consequent disappointment (T.H. Kim, 2018). In addition, the theta wave increases when the eyes are closed, and this is commonly observed in a state of sleepiness, which is the first stage of sleep (Vaitl et al., 2005; Park and Sung, 2006; Gruzelier, 2009). The theta wave is also known to be functionally related to the encoding and retrieval of information in the work memory (Vernon et al., 2003). RT decreased in this study not because the activities of cutting plants are high-level tasks that require the encoding and retrieval of information and solving problems, but because they are the tasks that can be stably performed, and thus did not cause anxiety in this study. In addition, the theta wave decreases when the eyes are closed, which means that they are in a stable but awake state, not in a sleepy state. Utilizing these results, the activities of cutting plants can be applied to those who have low cognitive ability such as children, the elderly with dementia, and people with intellectual disability or those who need to reduce psychological burdens.

Changes in RA Before and After Performing the Activities

RA before and after performing the activities was analyzed, but there was no statistically significant difference (Table 3).

Changes in RB, RLB, RMB and RHB Before and After Performing the Activities

RB before and after performing the activities was analyzed, and RB in F4 ($p = .009$) and O1 ($p = .030$) statistically significantly increased after performing the activities compared to the value before performing the activities (Table 4).

Table 3. Changes in Relative power of alpha (RA) waves before and after plant cutting work

Brain lobe	Site	M±SD (μV2)		t	p
		Before	After		
Prefrontal lobe	Fp1 ^z	0.196±0.061	0.187±0.043	1.134	.265
	Fp2	0.195±0.050	0.197±0.063	-0.177	.861
Frontal lobe	F3	0.191±0.050	0.191±0.063	-0.027	.979
	F4	0.199±0.050	0.198±0.065	0.093	.927
	F7	0.198±0.045	0.192±0.039	1.147	.259
	F8	0.192±0.034	0.196±0.053	-0.555	.583
	Fz	0.202±0.061	0.208±0.074	-0.620	.540
	T3	0.195±0.029	0.195±0.036	0.037	.971
Temporal lobe	T4	0.199±0.038	0.194±0.046	0.839	.407
	T5	0.251±0.076	0.258±0.097	-0.589	.560
	T6	0.269±0.104	0.276±0.125	-0.598	.554
	P3	0.267±0.104	0.274±0.118	-0.463	.646
Parietal lobe	P4	0.287±0.125	0.291±0.127	-0.314	.756
	Pz	0.255±0.098	0.253±0.139	0.139	.891
	O1	0.271±0.083	0.281±0.116	-0.828	.413
Occipital lobe	O2	0.259±0.106	0.273±0.122	-1.096	.281

^zSee Figure 2 for the detailed position.*Significant at $p < .05$ level by paired t-test.**Table 4.** Changes in Relative power of beta (RB) waves before and after plant cutting work

Brain lobe	Site	M±SD (μV2)		t	p
		Before	After		
Prefrontal lobe	Fp1 ^z	0.222±0.054	0.231±0.051	-0.979	.335
	Fp2	0.224±0.056	0.230±0.051	-0.659	.514
Frontal lobe	F3	0.227±0.051	0.232±0.049	-0.639	.527
	F4	0.219±0.048	0.235±0.050	-2.751	.009*
	F7	0.220±0.045	0.231±0.052	-1.356	.184
	F8	0.227±0.054	0.234±0.058	-0.844	.404
	Fz	0.217±0.050	0.227±0.044	-1.691	.100
	T3	0.236±0.062	0.246±0.063	-1.289	.206
Temporal lobe	T4	0.228±0.055	0.245±0.061	-1.973	.057
	T5	0.220±0.058	0.232±0.068	-1.959	.058
	T6	0.212±0.050	0.222±0.054	-1.461	.153
	P3	0.214±0.054	0.223±0.056	-1.353	.185
Parietal lobe	P4	0.212±0.058	0.218±0.053	-1.366	.181
	Pz	0.220±0.067	0.220±0.054	0.038	.970
	O1	0.216±0.057	0.230±0.073	-2.259	.030*
Occipital lobe	O2	0.217±0.060	0.222±0.050	-0.786	.437

^zSee Figure 2 for the detailed position.*Significant at $p < .05$ level by paired t-test.

There was no statistically significant change in RLB in all the measured areas (Table 5). RMB in F4 ($p=.021$) and T4 ($p=.029$) (Table 6), and RHB in F4 ($p=.015$) and O1 ($p=.034$) statistically significantly increased after performing the activities compared to the value before performing the activities (Table 7).

RB (relative power of beta) tends to increase more mainly in the parietal lobe in a state of arousal or when doing a conscious act than in a stable state (Yeon, 2013). RMB (relative power of mid beta) is known to increase when meditating,

Table 5. Changes in Relative power of low beta (RLB) waves before and after plant cutting work

Brain lobe	Site	M±SD (μV2)		t	p
		Before	After		
Prefrontal lobe	Fp1 ^z	0.067±0.013	0.067±0.009	-0.349	.729
	Fp2	0.066±0.012	0.067±0.009	-0.145	.885
Frontal lobe	F3	0.067±0.013	0.067±0.012	0.388	.701
	F4	0.068±0.013	0.067±0.009	0.483	.632
	F7	0.068±0.011	0.069±0.006	-0.592	.557
	F8	0.069±0.012	0.069±0.010	-0.190	.851
	Fz	0.067±0.012	0.066±0.011	0.301	.765
	T3	0.068±0.012	0.070±0.009	-0.589	.560
Temporal lobe	T4	0.068±0.011	0.069±0.010	-0.497	.623
	T5	0.066±0.014	0.067±0.014	-0.618	.540
	T6	0.065±0.014	0.067±0.016	-0.909	.370
	P3	0.069±0.014	0.070±0.016	-0.586	.562
Parietal lobe	P4	0.069±0.017	0.071±0.021	-0.857	.397
	Pz	0.071±0.016	0.067±0.021	1.183	.245
Occipital lobe	O1	0.067±0.015	0.067±0.021	-0.248	.806
	O2	0.065±0.018	0.069±0.021	-1.071	.292

^zSee Figure 2 for the detailed position.*Significant at $p < .05$ level by paired t-test.**Table 6.** Changes in Relative power of mid beta (RMB) waves before and after plant cutting work

Brain lobe	Site	M±SD (μV2)		t	p
		Before	After		
Prefrontal lobe	Fp1 ^z	0.078±0.014	0.083±0.017	-2.006	.053
	Fp2	0.079±0.019	0.083±0.020	-1.464	.152
Frontal lobe	F3	0.080±0.017	0.081±0.016	-0.343	.734
	F4	0.078±0.015	0.082±0.015	-2.425	.021*
	F7	0.079±0.013	0.082±0.015	-1.305	.201
	F8	0.080±0.017	0.083±0.021	-1.276	.210
	Fz	0.077±0.015	0.078±0.014	-0.466	.644
	T3	0.086±0.026	0.089±0.024	-1.104	.277
Temporal lobe	T4	0.081±0.017	0.088±0.023	-2.284	.029*
	T5	0.082±0.029	0.084±0.027	-1.118	.272
	T6	0.078±0.023	0.080±0.018	-0.615	.542
	P3	0.079±0.022	0.082±0.024	-1.316	.197
Parietal lobe	P4	0.078±0.024	0.079±0.023	-0.677	.503
	Pz	0.078±0.022	0.079±0.022	-0.381	.705
Occipital lobe	O1	0.080±0.027	0.084±0.034	-1.737	.091
	O2	0.075±0.021	0.079±0.016	-1.424	.164

^zSee Figure 2 for the detailed position.*Significant at $p < .05$ level by paired t-test.

and the higher the value, the higher the concentration level (Lee, 2011). RHB (relative power of high beta) is known to increase under severe stress or in an excited state (Jo, 2014). These three indicators are commonly related to arousal and concentration, and activities of cutting plants seem to induce concentration and a mentally awake state similar to meditation. Utilizing these results, the activities of cutting plants can be applied to those who experience psychological confusion, excessive unnecessary thinking or complicated problems, or those who use much mental energy in daily life.

Table 7. Changes in Relative power of high beta (RHB) waves before and after plant cutting work

Brain lobe	Site	M±SD (μV2)		t	p
		Before	After		
Prefrontal lobe	Fp1 ^z	0.103±0.404	0.107±0.038	-0.540	.593
	Fp2	0.103±0.039	0.016±0.036	-0.352	.727
Frontal lobe	F3	0.105±0.036	0.109±0.038	-0.713	.481
	F4	0.100±0.034	0.110±0.039	-2.557	.015*
	F7	0.100±0.033	0.106±0.038	-1.099	.280
	F8	0.104±0.038	0.108±0.040	-0.585	.563
	Fz	0.099±0.036	0.107±0.039	-1.785	.083
	T3	0.107±0.037	0.113±0.043	-1.124	.269
Temporal lobe	T4	0.105±0.039	0.114±0.043	-1.487	.146
	T5	0.098±0.031	0.107±0.042	-1.985	.055
	T6	0.094±0.023	0.102±0.040	-1.442	.159
	P3	0.093±0.031	0.099±0.034	-1.153	.257
Parietal lobe	P4	0.094±0.032	0.098±0.032	-1.233	.226
	Pz	0.102±0.032	0.097±0.032	-0.147	.884
	O1	0.095±0.030	0.106±0.041	-2.207	.034*
Occipital lobe	O2	0.102±0.058	0.102±0.038	0.038	.970

^zSee Figure 2 for the detailed position.*Significant at $p < .05$ level by paired t-test.**Table 8.** Changes in Relative power of gamma (RG) waves before and after plant cutting work

Brain lobe	Site	M±SD (μV2)		t	p
		Before	After		
Prefrontal lobe	Fp1 ^z	0.178±0.134	0.198±0.158	-0.874	.388
	Fp2	0.176±0.128	0.196±0.152	-0.898	.375
Frontal lobe	F3	0.203±0.157	0.218±0.182	-0.614	.544
	F4	0.178±0.131	0.200±0.155	-1.194	.241
	F7	0.161±0.116	0.172±0.129	-0.657	.516
	F8	0.169±0.120	0.177±0.144	-0.411	.683
	Fz	0.175±0.122	0.194±0.164	-1.054	.299
	T3	0.190±0.130	0.200±0.150	-0.492	.626
Temporal lobe	T4	0.180±0.123	0.199±0.151	-0.880	.385
	T5	0.167±0.132	0.181±0.150	-0.845	.404
	T6	0.153±0.113	0.152±0.121	0.066	.948
	P3	0.145±0.112	0.154±0.123	-0.507	.616
Parietal lobe	P4	0.148±0.103	0.155±0.124	-0.435	.666
	Pz	0.172±0.129	0.209±0.187	-1.342	.188
	O1	0.143±0.090	0.170±0.129	-1.562	.128
Occipital lobe	O2	0.148±0.109	0.158±0.133	-0.663	.512

^zSee Figure 2 for the detailed position.*Significant at $p < .05$ level by paired t-test.

Changes in RG Before and After Performing the Activities

RG before and after performing the activities was analyzed, but there was no statistically significant difference (Table 8).

Table 9. Changes in Ratio of SMR to theta (RST) waves before and after plant cutting work

Brain lobe	Site	M±SD (μV2)		t	p
		Before	After		
Prefrontal lobe	Fp1 ^z	0.202±0.132	0.221±0.122	-0.840	.407
	Fp2	0.199±0.129	0.216±0.105	-0.845	.404
Frontal lobe	F3	0.208±0.085	0.245±0.137	-1.661	.106
	F4	0.201±0.107	0.233±0.124	-2.358	.024*
	F7	0.180±0.068	0.199±0.099	-1.301	.202
	F8	0.188±0.077	0.225±0.134	-1.742	.091
	Fz	0.188±0.077	0.229±0.129	-2.653	.012*
	T3	0.221±0.120	0.278±0.193	-2.329	.026*
Temporal lobe	T4	0.213±0.137	0.266±0.181	-1.935	.061
	T5	0.235±0.137	0.291±0.202	-2.321	.026*
	T6	0.218±0.113	0.301±0.306	-2.023	.051
	P3	0.246±0.193	0.290±0.225	-1.075	.290
Parietal lobe	P4	0.271±0.223	0.327±0.303	-1.060	.297
	Pz	0.281±0.215	0.294±0.199	-0.325	.747
Occipital lobe	O1	0.213±0.105	0.333±0.340	-2.473	.019*
	O2	0.203±0.095	0.306±0.293	-2.503	.017*

^zSee Figure 2 for the detailed position.*Significant at $p < .05$ level by paired t-test.

Changes in RST, RMT and RSMT Before and After Performing the Activities

RST before and after performing the activities was analyzed, and RST in F4 ($p=.024$), Fz ($p=.012$), T3 ($p=.026$), T5 ($p=.026$), O1 ($p=.019$) and O2 ($p=.017$) statistically significantly increased after performing the activities compared to the value before performing the activities. RST in the rest areas also tended to increase, although there was no statistically significant difference (Table 9).

RMT before and after performing the activities was analyzed, and RMT in F4 ($p=.024$), Fz ($p=.012$), T3 ($p=.026$), T5 ($p=.026$), O1 ($p=.019$) and O2 ($p=.017$) statistically significantly increased after performing the activities compared to the value before performing the activities. RMT in the rest areas tended to increase, although there was no statistically significant difference (Table 10).

RSMT before and after performing the activities was analyzed, and RSMT in F4 ($p=.007$), Fz ($p=.016$), T4 ($p=.046$), O1 ($p=.012$) and O2 ($p=.007$) statistically significantly increased after performing the activities compared to the value before performing the activities. RSMT in the rest areas also tended to increase, although there was no statistically significant difference (Table 11).

RST (ratio of SMR to theta spectrum) occurs when attention reaches its peak (J.E. Kim, 2018), and often occurs while meditating in a nervous state (Lee, 2012). RMT (ratio of mid beta to theta) involves in attention and concentration, and the higher the RMT value, the higher the concentration level (Lee, 2011). RMT is known to increase when concentrating on one thing such as calculation and mental arithmetic or when focusing on and paying attention to a certain object (J.E. Kim, 2018). RSMT (ratio of SMR~mid beta to theta) is also another objective indicator of the state of concentration (Jo, 2014; Lee, 2011; Yeon, 2013). The higher the RSMT value, the higher the concentration level (Lubar, 1991). Therefore, the significant increase in RST, RMT and RSMT can be attributed to the increased attention and concentration level after performing the activities of cutting plants, compared to the level before performing the activities. In addition, the level also significantly increased in the frontal lobe and the occipital lobe, which seems to indicate that the activities of cutting plants

Table 10. Changes in Ratio of mid beta to theta (RMT) waves before and after plant cutting work

Brain lobe	Site	M±SD (μV2)		t	p
		Before	After		
Prefrontal lobe	Fp1 ^z	0.256±0.216	0.303±0.239	-0.840	.407
	Fp2	0.258±0.218	0.296±0.220	-0.845	.404
Frontal lobe	F3	0.265±0.146	0.327±0.233	-1.661	.106
	F4	0.242±0.162	0.306±0.200	-2.358	.024*
	F7	0.222±0.133	0.250±0.158	-1.301	.202
	F8	0.230±0.129	0.300±0.245	-1.742	.091
	Fz	0.227±0.122	0.293±0.213	-2.653	.012*
	T3	0.324±0.332	0.409±0.387	-2.329	.026*
Temporal lobe	T4	0.277±0.232	0.383±0.331	-1.935	.061
	T5	0.338±0.336	0.402±0.323	-2.321	.026*
	T6	0.286±0.199	0.376±0.334	-2.023	.051
	P3	0.306±0.261	0.351±0.273	-1.075	.290
Parietal lobe	P4	0.323±0.300	0.362±0.272	-1.060	.297
	Pz	0.328±0.300	0.367±0.235	-0.325	.747
Occipital lobe	O1	0.283±0.219	0.461±0.513	-2.473	.019*
	O2	0.250±0.145	0.365±0.292	-2.503	.017*

^zSee Figure 2 for the detailed position.*Significant at $p < .05$ level by paired t-test.**Table 11.** Changes in Ratio of SMR~mid beta to theta (RSMT) waves before and after plant cutting work

Brain lobe	Site	M±SD (μV2)		t	p
		Before	After		
Prefrontal lobe	Fp1 ^z	0.458±0.347	0.524±0.353	-1.379	.177
	Fp2	0.456±0.345	0.511±0.318	-1.290	.206
Frontal lobe	F3	0.472±0.230	0.572±0.369	-1.727	.093
	F4	0.443±0.268	0.539±0.323	-2.874	.007*
	F7	0.402±0.201	0.449±0.256	-1.044	.304
	F8	0.419±0.206	0.524±0.377	-1.918	.064
	Fz	0.414±0.197	0.521±0.340	-2.535	.016*
	T3	0.545±0.442	0.687±0.570	-1.801	.081
Temporal lobe	T4	0.490±0.369	0.649±0.505	-2.066	.046*
	T5	0.573±0.460	0.693±0.513	-1.305	.201
	T6	0.505±0.307	0.678±0.612	-1.895	.067
	P3	0.551±0.441	0.641±0.484	-0.859	.396
Parietal lobe	P4	0.595±0.510	0.690±0.544	-0.909	.370
	Pz	0.609±0.504	0.660±0.408	-0.737	.466
Occipital lobe	O1	0.496±0.318	0.794±0.808	-2.662	.012*
	O2	0.453±0.234	0.671±0.551	-2.857	.007*

^zSee Figure 2 for the detailed position.*Significant at $p < .05$ level by paired t-test.

increased not only focused attention, but also the overall attention including unfocused attention (Lee, 2016). This is very similar to meditation, and the activities of cutting plants seem to be very effective in increasing attention to one topic. Utilizing these results, the activities of cutting plants can be applied for the purposes of strengthening attention and increasing concentration.

There is still a limitation. Since only brain wave indicators were used in analysis in this study, it is difficult to identify

the correlation between subjective cognitive conditions and neurophysiological conditions. In addition, changes in the brain wave indicators depending on the area where brain waves occur were not considered in this study. Despite these limitations, the activities of cutting plants were found, in this study, to increase concentration through conscious activities without causing intellectual anxiety or psychological burdens, which is meaningful.

Conclusion

This study was conducted to analyze changes in brain waves before and after performing the activities of plants cutting, targeting a total of 34 adults, to identify the effects of the activities and to support the selection of target subjects. RT decreased after performing the activities of plants cutting, while RB, RMB, RHB, RST, RMT and RSMT increased. However, there was no statistically significant change in RA, RLB and RG. RT decreased in this study not because the activities were high-level tasks, but because they were the tasks that can be stably performed, and thus did not cause anxiety. This indicates that the activities of cutting plants can be applied to those who have low cognitive ability such as children, the elderly with dementia and people with intellectual disability or those who need to reduce psychological burdens through the activities. RB, RMB and RHB increased in this study, which induces concentration and a mentally awake state similar to meditation, and thus the activities of cutting plants can be applied to those who experience psychological confusion, excessive unnecessary thinking or complicated problems, or those who use much mental energy in daily life. RST, RMT and RSMT also increased, which indicates that the concentration level increased. Therefore, the activities of cutting plants can be applied for the purposes of strengthening attention and increasing concentration. In this study, the activities of plants cutting were found to increase concentration through conscious activities without causing intellectual anxiety or psychological burdens, which is meaningful.

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