The Effect of Making Pressed Flower Fans on the Prefrontal Electroencephalogram Activity of University Students

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ABSTRACT

Background and objective: This study was conducted to investigate the effect of a horticultural activity program using pressed flowers on the prefrontal electroencephalogram (EEG) activity of university students.

Methods: This study was conducted from August 5 to October 12, 2021 on 31 students of D University. The program required the subjects to wear an EEG device and make fans decorated with pressed flowers. The program was divided into three stages: ① preparation stage: looking at a wall coated in white paint (2 minutes), ② working stage: designing pressed flowers on a fan (5 minutes), and ③ appreciation stage: looking at and appreciating the fans they made, decorated in pressed flowers (3 minutes). Total relative values were analyzed by dividing the sections of prefrontal \( \theta \), \( \alpha \), \( \beta \), and \( \gamma \) waves into preparation, work, and appreciation, excluding delta waves that increase during sleep.

Results: Theta waves, which reflect the state of meditation, significantly increased on both left (\( p = .007 \)) and right (\( p = .002 \)) in the appreciation stage. On the other hand, there was a significant difference in alpha waves in the work stage (left: \( p < .001 \), right: \( p < .001 \)). In addition, it was confirmed that beta waves reflecting attention, arousal, and active mental state increased in the work stage and decreased in the appreciation stage (left: \( p = .048 \), right: \( p = .010 \)). In the case of gamma wave, there was no significant change. By gender, there was a significant decrease in theta waves (left: \( p = .034 \)) and a significant increase in alpha waves on the left among male students (left: \( p = .026 \)). For female students, theta waves significantly decreased in the work stage on the right (right: \( p = .038 \)), and alpha waves significantly increased in the work stage (left: \( p = .002 \), right: \( p = .007 \)).

Conclusion: As described above, it was possible to investigate the effect of horticultural activities using pressed flowers in each of the activity stages such as preparation, work, and appreciation on changes in the prefrontal EEG of university students.

Keywords: appreciation, EEG, preparation, work

Introduction

According to Erikson’s stages of psychosocial development, college years are when one must perform the basic development tasks of establishing self-identity and personal maturity (Kim, 2009). During this time, university students feel psychological burden due to issues such as choosing their future career path, anxiety about the future, and adapting to changes in the social environment (Kim et al., 2014). They are also facing constant life stress in the rapid changes of society in addition to adjusting to college life, such as academic achievement, career path, and new interpersonal relations (Lee, 2012). Stress of university students makes it difficult to adjust to college life and causes problems such as anxiety and depression. University students sometimes smoke or drink to cope with such stress, and some even end up being addicted (Bae, 2019). This stress university students suffer from as well as maladaptive coping...
is known to deteriorate academic achievement and life satisfaction (Suldo et al., 2008). Stressful life events cause psychological and physical problems for individuals, making it difficult to adjust to everyday life. Therefore, it is an important matter in their lives to properly handle stress toward a positive direction during college years (Kim, 2012).

Horticultural activities using plants have a positive effect on the stress, depression, and self-esteem of participants (Park et al., 2016), reduce anxiety or depression, and increase life satisfaction (Kim et al., 2012). Floral decoration increases stability of adults and is also effective in relieving stress (Tak, 2006). Floral design is classified into cut flowers, potted flowers, and preserved flowers. Pressed flowers, a type of preserved flowers, are real flowers dried to be used semi-permanently but are still natural compared to artificial flowers (Condon, 1962). Art activities using pressed flowers are a type of plastic arts formed by emphasizing the pictorial mood after artificially pressing and drying the flowers, leaves, and stems of the plant body, using physical methods or chemical treatment (Yang et al., 1997). One may feel the joy of creation in the process, and it is a creative arts activity as good as painting but requires relatively less time or effort (Yang et al., 1997). It can be used easily by anyone in daily life and also be applied to household items in addition to artwork (Condon, 1962). Working with pressed flowers relaxes the anxious mind and body, lowering the accelerated vitality and forming a balance (Kim et al., 2012). There is a study result that collaborative programs of pressed flowers and floral decoration are also effective in improving life satisfaction and interpersonal relations among the elderly in convalescent hospitals (Jeong et al., 2017).

Recently, various studies are being conducted to examine the physiological changes in emotional functions, and among tests that can objectively examine the physiological phenomena of humans, electroencephalogram (EEG) provides quantitative data for psychophysiological research of quantitative brain functions (Chang and Chen, 2005). Spontaneous electrical changes occur in response to stimulation in the brain, which is a central nervous system, and these changes are measured through EEG. EEG is an objective and non-invasive method that records real-time electrical changes that occur due to the brain cell activity and can sequentially identify constantly changing brain activity (Yoon, 2010). The frontal lobe is the part that directly creates the mind, which is the human spirit, by performing a key role in cognitive function and thinking, and also generates human creativity and is closely related to emotions like pleasure. Frontal EEG can be used as an important indicator in interpreting human mental activity (Bak, 2011). Meanwhile, most of the traditional devices used to acquire EEG signals used at least 16 electrodes, but the process or actions required for measurement are too many or complicated, making it difficult to apply to children or other participants that are sensitive to stimulation (Badcock et al., 2013; Johnstone et al., 2012). A simplified EEG device produces consistent measured values even with repeated measurements, and these measured values are highly correlated with those of the traditional multichannel EEG device (Ratti et al., 2017; Rogers et al., 2016), and thus can effectively measure and classify various cognitive conditions such as relaxation, attention, sleeping, and awakening (Fernandez-Blanco et al., 2020; Kang et al., 2015; Peng et al., 2019).

Accordingly, this study examines the effect of making pressed flower fans on the activation of prefrontal $\theta$ waves, $\alpha$ waves, $\beta$ waves, and $\Upsilon$ waves of university students and investigate the psychophysiological effectiveness of horticultural activities using preserved flowers.

**Research Methods**

**Subjects**

This study was conducted on 31 students of D University located in G city, who gave consent to participate in the study after explaining the purpose, method, and duration of the experiment. The average age of the subjects was 22.3 ± 0.6 years, and there were 15 male (48.4%) and 16 female students (51.6%). The participants were recruited by making and hanging up open lab promotion banners and leaflets and announcing the recruitment on social media, school clubs, group chats and cafes, after which the experiment was conducted from August 5 to October 12, 2021. A reservation system was implemented to schedule the experiment so that students would not have to wait for
a long time or avoid crowdedness. The study was conducted in a 30m$^2$ laboratory under restricted conditions where the subjects could concentrate on the experiment. The participants selected were those in their 20s whose frontal lobes are being completed (Ha and Park, 2018), are not taking drugs due to illness, and have no particular brain diseases or color perception issue. Those who consumed alcohol or caffeine within 2 hours before the experiment were excluded.

**Tools**

**Program design and implementation**

The pressed flower fan making program was developed to design, attach, and appreciate pressed flowers on a fan. The experiment was conducted in stages of preparation, work, and appreciation (Table 1). In the preparation stage, the subjects were to look at the wall coated in white paint for 2 minutes to stabilize the brain waves. In the work stage, they designed fans using pressed flowers for 5 minutes. Then finally, in the appreciation stage, they were to stare at their work for 3 minutes.

Subjects who voluntarily consented to the experiment participated after filling out the consent form, reading the experiment manual, and being fully aware of the precautions for EEG measurement. Prior to the experiment, the students were briefly explained about the process of making a pressed flower fan to facilitate the process. Then they put on the EEG measuring device and participated in activities such as designing, decorating and appreciating pressed flowers (*Hydrangea macrophylla*, *Spirea prunifolia*, *Osmunda japonica*, *Cardiospermum halicacabum*) on a fan (15 × 25 cm). When starting each stage, a signal was given to start, such as 'You may begin', 'You may start the pressed flower activity', and 'Please stop and stare' in a small voice (Fig. 1).

**Assessment tool**

This study measured prefrontal EEG in each activity stage (preparation, work, appreciation) using NeuroNicle E1 (LAXTHA Inc., Korea). The reference and ground electrodes were attached to the right earlobe in the form of tongs, and a band-type measuring device with two electrodes was placed on Fp1 and Fp2 (prefrontal) according to the international 10-20 system for EEG electrode placement (Jasper, 1958). Only data with noises such as eye blinking removed was used in the analysis.

EEG frequency patterns used in the analysis were θ wave (4-8 Hz), α wave (8-13 Hz), β wave (13-30 Hz), and ϒ wave (30-50 Hz) excluding delta that increases in deep sleep (Yoon, 1999). The frequency value (Hz) is displayed on the horizontal axis, while the vertical axis displays the power value (㎶) representing the degree of appearance of the frequency component (Min and Hur, 2021). Relative power, which is the ratio of the absolute power of each frequency band divided by that of the entire frequency band, was comparatively analyzed as a dependent variable.

**Data analysis**

EEG indices were calculated by primarily using the time series analysis software TeleScan (LAXTHA Inc., Korea). The data collected was analyzed using SPSS (version 19.0, IBM, USA), with normality test in the preparation stage analyzed with the Kolmogorov-Smirnov test and the mean difference in each activity stage analyzed with repeated measures ANOVA.

| Table 1. Composition of pressed flower program |
|-----------------------------------------------|
| Progress | Time (min) | Activity |
|----------|------------|----------|
| Preparation | 2 | Looking at the wall |
| Work | 5 | Making pressed flower fan |
| Appreciation | 3 | Viewing at the fan |

**Fig. 1.** The stage of an experiment.
Results and Discussion

Normality test

Normality test was conducted on EEG data of each subject collected in the preparation stage to analyze EEG changes in each activity stage. All of \(\theta\), \(\alpha\), \(\beta\), and \(\gamma\) waves followed normal distribution \((p > .05, \text{Table 2})\).

EEG changes of subjects in each activity stage

The results of comparing the relative values by dividing sections of preparation (2 minutes), work (5 minutes), and appreciation (3 minutes) in the raw data of 31 university students are as follows. \(\theta\) waves were \(.67 \pm .14\) in preparation, \(.62 \pm .12\) in work, and \(.70 \pm .12\) in appreciation on the left FP1, and \(.67 \pm .14\) in preparation, \(.64 \pm .13\) in work, and \(.72 \pm .11\) in appreciation on the right FP2, showing a significant difference \((p < .01)\). \(\alpha\) waves were \(.14 \pm .05\) in preparation, \(.17 \pm .03\) in work, and \(.14 \pm .05\) in appreciation on the left FP1, and \(.14 \pm .05\) in preparation, \(.17 \pm .03\) in work, and \(.13 \pm .05\) in appreciation on the right FP2, showing a significant difference \((p < .01)\). \(\beta\) waves were also \(.13 \pm .09\) in preparation, \(.14 \pm .07\) in work, and \(.11 \pm .06\) in appreciation on the left FP1, and \(.13 \pm .09\) in preparation, \(.14 \pm .08\) in work, and \(.10 \pm .06\) in appreciation on the right FP2, showing a significant difference \((p < .05)\). As shown above, \(\theta\), \(\alpha\), and \(\beta\) waves showed different relative values according to activity stage on both left and right, but there was no difference in the case of \(\gamma\) waves (Table 3).

A Bonferroni post-hoc test was conducted to examine the average estimated values of effect size in each stage. There was a significant difference in \(\alpha\) waves for preparation and work \((p < .05)\). There was no significant difference in the changes between preparation and appreciation. There was a significant difference in \(\theta\) waves \((p < .01)\), \(\alpha\) waves \((p < .001)\), and \(\beta\) waves \((p < .05)\) for work and appreciation. \(\theta\) waves occur while dreaming or meditating and exist between conscious and unconscious (Kim et al., 2005), and thus they were activated during appreciation compared to

| Item     | Preparation stage | \(p\)  |
|----------|-------------------|--------|
| \(\theta\) wave | Left | .65 ± .20 | .660\text{ns} |
| \(\alpha\) wave | Right | .66 ± .18 | .762\text{ns} |
| \(\beta\) wave | Left | .13 ± .06 | .650\text{ns} |
| \(\gamma\) wave | Right | .12 ± .05 | .810\text{ns} |

\text{ns} Non-significant by Kolmogorov-Smirnov test.

Table 2. Normality test of the data collected in the preparation stage \((N = 31)\)

| EEG     | Activity stage | Preparation | Work | \(p\)  | Appreciation | \(p\)  |
|---------|----------------|-------------|------|--------|-------------|--------|
| \(\theta\) wave | Left | .67 ± .14 | .62 ± .12 | .259\text{ns} | .70 ± .12 | .661\text{ns} | .002** | .007** |
| \(\alpha\) wave | Right | .67 ± .14 | .64 ± .13 | .454\text{ns} | .72 ± .11 | .100\text{ns} | .002** | .002** |
| \(\beta\) wave | Left | .14 ± .05 | .17 ± .03 | .001** | .14 ± .05 | 1.000** | .000*** | .000*** |
| \(\gamma\) wave | Right | .14 ± .05 | .17 ± .03 | .028 | .13 ± .05 | 1.000** | .000*** | .001** |

\text{ns} Pairwise comparison of preparation and work stages by Bonferroni.

Table 3. Changes in electroencephalogram of the subjects by each activity stage \((N = 31)\)

\(\text{ns}\) Comparison by activity stages by repeated measures design ANOVA.

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work. $\alpha$ waves are generated in a healthy and stress-free state, when the body and mind are in harmony with the brain relaxed along with muscles (Kim et al., 2005). As such, this study also revealed that a horticultural activity or appreciation could help relax, and thus these waves were activated more in the stages of work and appreciation than preparation. Huh (2014) claimed that an increase in certain waves tend to lead to a decrease in other brain waves. The fact that $\alpha$ waves increased in the work stage and $\theta$ waves increased in the appreciation stage indicates that the subjects felt relaxed and stabilized while working with pressed flowers, and their internal attention such as meditation also increased while they appreciated their work.

### EEG changes in each activity stage by gender

$\alpha$ waves were generally activated without any gender difference when arranging flowers and transplanting plants into pots. However, $\theta$, $\beta$, and $\gamma$ waves showed slightly different activity by gender (Yun et al., 2021; Choi, 2022). Therefore, this study also analyzed the changes in the relative values of EEG in each activity stage by gender. For male students, $\theta$ waves were $.67 \pm .16$ in preparation, $.60 \pm .11$ in work, and $.68 \pm .14$ in appreciation on the left FP1, and $\alpha$ waves were $.14 \pm .04$ in preparation, $.17 \pm .03$ in work, and $.14 \pm .05$ in appreciation on the left FP1, showing a significant difference ($p < .05$, Table 4). According to Bradshaw and Norman Nettleton (1981), the left hemisphere is sequential, analytical, and time-dependent, and thus it experiences events as a sequence of multiple units that appear in order. On the other hand, the right hemisphere is comprehensive and holistic, perceiving the overall form. It seems male students might have approached pressed flower work sequentially and analytically. This result is different from the study in which $\alpha$ waves were activated on both left and right when arranging flowers and planting plants (Yun et al., 2021; Choi, 2022). Moreover, there was no significant difference in the activity of other brain waves. The Bonferroni post-hoc test also did not show a significant difference.

For female students, the results are as follows. $\theta$ waves were $.69 \pm .11$ in preparation, $.66 \pm .14$ in work, and $.75 \pm .10$ in appreciation on the right FP2, showing a significant difference ($p < .05$). $\alpha$ waves were $.13 \pm .05$ in preparation, $.18 \pm .04$ in work, and $.14 \pm .04$ in appreciation on the left FP1, and $\alpha$ waves were $.14 \pm .04$ in preparation, $.17 \pm .03$ in work, and $.14 \pm .05$ in appreciation on the left FP1, showing a significant difference ($p < .05$, Table 4). The difference in activity when decorating a fan using pressed flowers can be explained by the fact that the brain increases creativity and telepathy when $\theta$ waves and $\alpha$ waves intersect (Klimesch, 1995). Female students showed similar results (Yun et al., 2021; Choi, 2022) in each activity stage even when they participated in flower arrangement.

### Table 4. Changes in electroencephalogram of male students by activity stage (n=15)

| EEG          | Activity stage | Preparation | Work     | Appreciation | $p^w$ | $p^y$ | $p^z$ |
|--------------|----------------|-------------|----------|--------------|-------|-------|-------|
| $\theta$ wave (4-8Hz) | Left           | .67 ± .16   | .60 ± .11 | .278$^a$     |       |       | .057$^c$|
|              | Right          | .65 ± .17   | .60 ± .12 | .843$^a$     |       |       | .097$^c$|
| $\alpha$ wave (8-13Hz) | Left           | .14 ± .04   | .17 ± .03 | .084$^a$     |       |       | .118$^c$|
|              | Right          | .14 ± .05   | .16 ± .03 | .414$^a$     |       |       | .191$^c$|
| $\beta$ wave (13-30Hz) | Left           | .14 ± .10   | .16 ± .07 | .928$^a$     |       |       | .084$^c$|
|              | Right          | .14 ± .11   | .16 ± .08 | 1.000$^a$    |       |       | .111$^c$|
| $\gamma$ wave (30-50Hz) | Left           | .06 ± .05   | .08 ± .05 | .644$^a$     |       |       | .109$^c$|
|              | Right          | .07 ± .05   | .08 ± .05 | 1.000$^a$    |       |       | .126$^c$|

*Pairwise comparison of preparation and work stages by Bonferroni
1Pairwise comparison of preparation and appreciation stages by Bonferroni
2Pairwise comparison of work and appreciation stages by Bonferroni
3Comparison by activity stages by repeated measures design ANOVA

$p > .05$, $p < .05$, $^* p < .01$, $^{**} p < .001$.  

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and planting in terms of preparation, appreciation, and work as classified in this study.

The results of this study were similar to the study revealing that art activities using preserved flowers boost mental and physical energy and provide mental stability (Kim, 2012), and that horticultural activities using dried flowers of various colors are effective in improving attention in addition to relieving mental and physical stress (Lee et al., 2013). The results are also in line with the study proving that floral design programs had a positive effect on stress relief and emotional stability of female high school students (Son et al., 2013). They are also consistent with the study that horticultural activities are effective in improving emotional behavior and social skills of people with intellectual disabilities (Lee and Kim, 2010) and that horticultural therapy using pressed flowers reduced helplessness by giving a sense of achievement in being able to create art with small flowers (Kim, 2005).

### Conclusion

This study analyzed EEG using pressed flowers, which are preserved flowers, as a pilot test to investigate the healing effects of plants by type of use and activity of flowers that serve as the medium of healing in horticultural therapy. The program was developed in three stages, making fans decorated with pressed flowers while wearing an EEG device: ① preparation stage: looking at a wall coated with white paint (2 minutes) ② work stage: designing pressed flowers on a fan (5 minutes) ③ appreciation stage: staring at and appreciating the fans they made, decorated in pressed flowers (3 minutes). Total relative values were analyzed by dividing the sections of prefrontal \( \theta \), \( \alpha \), \( \beta \), and \( \gamma \) waves into preparation, work, and appreciation, excluding delta waves that increase in sleep. The results showed that, in the pressed flower fan making program, \( \theta \) waves that appear dominant in a sleepy or hypnotic state decreased in the work stage, which involves designing pressed flowers of different colors and decorating them with tweezers (\( p < .01 \)). Moreover, \( \alpha \) waves of stability and relaxation increased (\( p \leq .001 \)), and \( \beta \) waves that reflect arousal and active mental state were activated (\( p < .05 \)). Quantitative data proved that working elaborately with tweezers and pressed flowers during the activities had a positive effect on attention in a stable, relaxed state. On the other hand, \( \theta \) waves increased in the appreciation stage compared to the work stage. This result suggests that internal attention increased during appreciation, and positive brain waves are activated more while working rather than appreciating. In other words, \( \theta \) waves were activated when simply appreciating the decorated fans, but \( \alpha \) waves and \( \beta \) waves related to stability, relaxation, and attention were activated more when actually doing the work. Therefore, it is necessary

### Table 5.

Changes in electroencephalogram of female students by activity stage (N = 16)

| EEG     | Activity stage | Preparation | Work      | \( p^2 \) | Appreciation | \( p^2 \) | \( p^2 \) |
|---------|----------------|-------------|-----------|-----------|-------------|-----------|-----------|
| \( \theta \) wave | Left          | .67 ± .12   | .65 ± .13 | 1.000\(^a\) | .71 ± .09   | .867\(^a\) | .064\(^a\) |
| (4-8Hz) | Right         | .69 ± .11   | .66 ± .14 | 1.000\(^a\) | .75 ± .10   | .386\(^a\) | .024\(^a\) |
| \( \alpha \) wave | Left          | .13 ± .05   | .18 ± .04 | .016\(^a\) | .14 ± .04   | 1.000\(^a\) | .001\(^a\) |
| (8-13Hz)| Right         | .14 ± .05   | .17 ± .04 | 1.000\(^a\) | .13 ± .04   | 1.000\(^a\) | .001\(^a\) |
| \( \beta \) wave | Left          | .13 ± .08   | .13 ± .07 | 1.000\(^a\) | .10 ± .05   | .695\(^a\) | .245\(^a\) |
| (13-30Hz)| Right        | .12 ± .08   | .12 ± .08 | 1.000\(^a\) | .09 ± .05   | .409\(^a\) | .101\(^a\) |
| \( \gamma \) wave | Left          | .06 ± .06   | .05 ± .03 | 1.000\(^a\) | .04 ± .03   | .464\(^a\) | 1.000\(^a\) |
| (30-50Hz)| Right        | .05 ± .05   | .05 ± .04 | 1.000\(^a\) | .04 ± .04   | .677\(^a\) | 1.000\(^a\) |

\( ^a \)Pairwise comparison of preparation and work stages by Bonferroni
\( ^b \)Pairwise comparison of preparation and appreciation stages by Bonferroni
\( ^c \)Comparison by activity stages by repeated measures design ANOVA
\( ^d \)\( p > .05 \), \( ^e \)\( p < .05 \), \( ^f \)\( p < .01 \), \( ^g \)\( p < .001 \).
to select activities that are focused on work or appreciation depending on not only the physical state of the subjects but also the therapeutic purpose. This study may be limited in that it only analyzed the effects of pressed flower work, while not comparing with other activities. In addition, it is also necessary to comparatively analyze different types of flowers, difficulty levels in pressed flower work, and types of artwork. Furthermore, in determining healing effectiveness, an approach based on medical science must be taken by medical specialists so that horticultural therapy can be established as a field of complementary and alternative medicine.

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