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Frontal Cortical Activity during Care Farming Activities of Adults Using Electroencephalogram

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Abstract. **The underlying therapeutic mechanisms of care farming activities have not been addressed using psychophysiological data. We aimed to understand frontal cortex activation in adults during care farming activities and to explore the psychophysiological effects. Using a randomized crossover study method, 20 adults (average age, 31.3 ± 9.8 years) participated in 10 care farming activities, (four gardening activities, three animal-mediated activities, and three off-farming activities) for 3 minutes each at an actual care farm. Electroencephalography (EEG) was performed during the activity, and emotional states were assessed using subjective emotional questionnaires after each activity. The EEG results revealed that alpha activity increased during gardening activities, such as organizing garden plots and planting plants. Spectral edge frequency 50, which predicts the degree of arousal, increased during interaction with dogs. The results of the subjective emotional questionnaire revealed that participants experienced positive emotions, such as vigor, comfort, naturalness, and relaxation, when participating in care farming activities compared with those while resting. Therefore, this study suggests that care farming activities can induce changes in the frontal cortex activation and positive emotional states in participants. This study elucidates the use of such activities to address mental health-related issues.**

Since the coronavirus disease pandemic in 2020, the worldwide prevalence of depression has been approximately 30% (Wu et al. 2021), thus raising concerns about mental health issues, especially among young adults (Ford et al. 2021; Owens et al. 2022). During the pandemic, a substantial number young adults sought assistance from mental health systems worldwide (Pfefferbaum and North 2020). Therefore, measures to strengthen protective factors, such as psychiatric rehabilitation and social support, should be considered as stress buffer mechanisms (Shanbehzadeh et al. 2021).

Numerous studies have revealed that contact with nature and the use of the natural environment contribute to the improvement and promotion of human health and well-being throughout life (Aerts et al. 2018; Mygind et al. 2019; Overbey et al. 2023). In particular, various scholars have suggested that nature has restorative effects. Attention restoration theory (ART) is one of the most well-known theories that explains the salutogenic potential of the natural environment. The theory posits that exposure to nature can restore depleted attention (Kaplan and Kaplan 1989). Additionally, ART suggests that spending time in a natural environment can improve involuntary attention by “recovering” the cognitive ability to focus and ultimately reduce psychosocial stress.

Similarly, Ulrich et al. (1991) developed the stress reduction theory, which proposed that viewing nature could engage individuals and relieve the stress of urban life without causing fatigue. Visual complexity, noise, and high levels of stimulation in urban environments can overload and arouse humans and induce stress. Conversely, passive engagement with the natural environment can reduce human physiological and psychological stress.

Wilson (1984) defined biophilia as “the innate tendency to focus on life and life-like processes” and observed that humans have an innate affinity for all living things in nature. Because the ART and stress reduction theory are evolutionary and fundamentally based on a biological framework, biophilia can provide a basis for supporting both hypotheses and explaining the benefits of nature to humans (Han 2001).

In this context, care farming is an intervention that improves mental and physical health by using various agricultural resources in the natural environment of a farm (Hine et al. 2008a, 2008b). A major therapeutic mechanism and essential intervention factor in care farming are the restorative effects of the natural environment (Murray et al. 2019; Steigen et al. 2016), which positively affect the well-being of many client groups with differing needs. Care farming can benefit overall well-being by reducing depression and anxiety through passive and active interactions with nature (Ellingsen-Dalskau et al. 2015; Leck et al. 2015; Pedersen et al. 2012). Several studies have reported reduced stress levels of individuals when participating in care farming and green care services (Gonzalez et al. 2010, 2011; Leck et al. 2015). However, these studies did not clearly explain the therapeutic mechanisms of care farming. Psychophysiological data should be used to determine the underlying mechanism; however, such studies are lacking. Therefore, we designed this study to investigate the psychophysiological responses of the participants by measuring their electroencephalography (EEG) signals during care farming activities.

Table 1. Descriptive information of participants who participated in the study.

Variable	Male (n = 7)	Female (n = 13)	Total (N = 20)
	Mean ± *SD*		
Age (years)	28.86 ± 8.03	32.62 ± 10.63	31.30 ± 9.76
Height[i] (cm)	175.31 ± 3.40	163.50 ± 6.56	167.85 ± 8.03
Body weight[ii] (kg)	73.44 ± 12.37	58.26 ± 9.09	63.85 ± 12.58
Body mass index[iii] ($kg·m^{-2}$)	24.69 ± 5.83	21.73 ± 2.76	21.90 ± 5.45

[i] Height was measured using an anthropometer (Ok7979; Samhwa, Seoul, South Korea) while the participant was not wearing shoes.
[ii] Body weight was measured using a body fat analyzer (ioi 353; Jawon Medical, Seoul, South Korea).
[iii] Body mass index was calculated using the following formula: [weight (kg)]/[height $(m)^2$].

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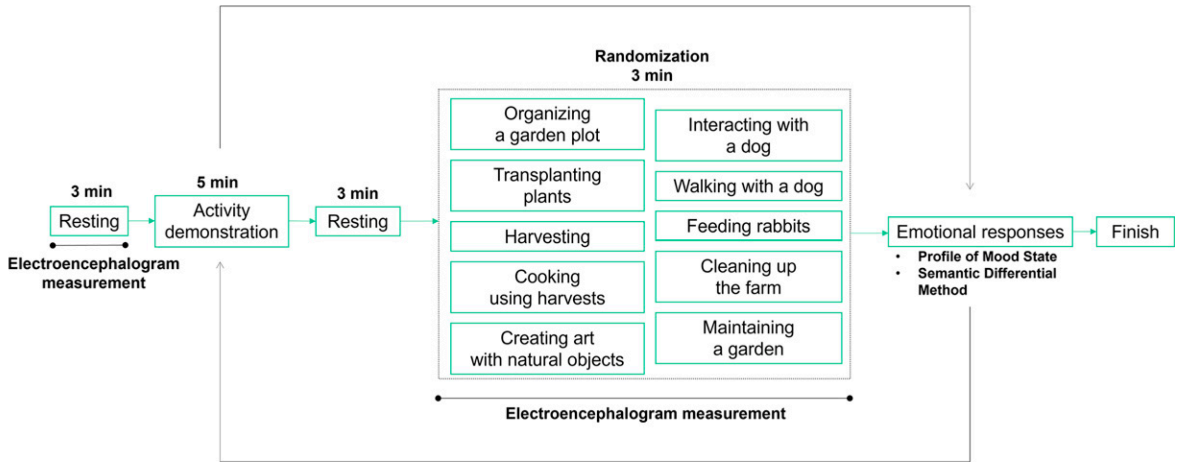

Fig. 1. The experimental protocol used in this study.

Table 2. Quantitative EEG parameters used in this study.

Parameter	Analysis methods
RA	Alpha (8–13 Hz)/total frequency (4–50 Hz)
RB	Beta (12–30 Hz)/total frequency (4–50 Hz)
RFA	Fast alpha (11–13 Hz)/total frequency (4–50 Hz)
RLB	Low beta (12–15 Hz)/total frequency (4–50 Hz)
SEF50	The frequency below which 50% of the power in the total frequency band (4–50 Hz)

EEG = electroencephalography; RA = relative alpha; RB = relative beta; RFA = relative fast alpha; RLB = relative fast beta; SEF50 = spectral edge frequency 50% of the total spectrum band.

Materials and Methods

Participants. Twenty adults (13 females and 7 males; age, 31.3 ± 9.8 years) without psychopathological disorders participated in this study (Table 1). Only right-hand-dominant adults participated in this study because differences in cortical activity associated with dominant and nondominant hand movements have been previously reported (Tarkka and Hallett 1990). Participants were asked to avoid eating for 2 h before the start of the experiment to reduce the effects of caffeine or other stimulants in food on cortical activity (Heckman et al. 2010).

Participants visited a care farm in Sejong City, Republic of Korea, and they received detailed explanations of the purpose and activities of the study from the researcher. Subsequently, participants completed a demographic questionnaire including age, sex, and medication information. Their height, weight, and body mass index were measured using a body composition analyzer (ioi 353; Jawon Medical, Gyeongsan, Republic of Korea). At the end of the experiment, participants received $10 as a reward. This study was approved by the Institutional Review Board of Konkuk University (7001355-202106-HR-442).

Experimental procedure and condition. The experiment was conducted at a care farm in Sejong City, South Korea (https://www.sejong.go.kr/prog/nongjang/adtc/sub02_02/55/view.do; accessed 20 Mar 2023). To conduct the experiment, a care farm with various agricultural resources such as vegetable gardens and greenhouses, animal resources such as chickens, dogs, peacocks, and rabbits, and facility resources such as cooking spaces and indoor classrooms was recruited in advance. The climatic environment of Sejong City during the experimental period was as follows: average temperature, 23.3 °C (±2.5 °C); average relative humidity, 81.7% (±12.3%); and average illumination, 2284.8 lx (±2526.7 lx).

First, the participants sat on a chair, and their resting EEG signals were measured for 3 min in a room with a white hardboard on the wall directly opposite to their faces. The participants performed the following 10 care farming activities according to the researcher's explanation (Fig. 1 and Supplemental Table 1): organizing a garden plot; transplanting plants; harvesting; cooking using harvests; creating art with natural objects; interacting with a dog; walking with a dog; feeding rabbits; cleaning up the farm; and maintaining a garden. Before performing each care farming activity, the participants rested on a chair for 3 min. After resting, participants performed each care farming activity for 3 min in random order, and they were subsequently asked to complete a questionnaire to record their emotional responses using the profile of mood states (POMS) and semantic differential method (SDM). The total duration of the experiment for each participant was approximately 90 min, and the entire experiment was conducted under the supervision of a farmer who was prepared for an emergency.

Measurement. The EEG data were recorded (bandpass, 0.5–100 Hz; sampling rate, 1000 Hz) with a wireless dry EEG device (Quick-20; Cognionics, San Diego, CA, USA). This device collects data by amplifying and processing electrical signals measured by attaching dry electrodes to the scalp of the participants. Dry electrodes reduce the risks of electric shock and discomfort for the participants (Kim et al. 2020).

To measure frontal cortex activation during care farming activities, EEG signals were acquired from two channels (F3 and F4) that could measure frontal cortex activation with a reference electrode (A1) according to the International 10-20 system (Fig. 2). The frontal cortex accounts for 30% of the total cortical area and is related to emotional, social, perceptual, and other processes (Carlén 2017). The essential function of the frontal cortex is

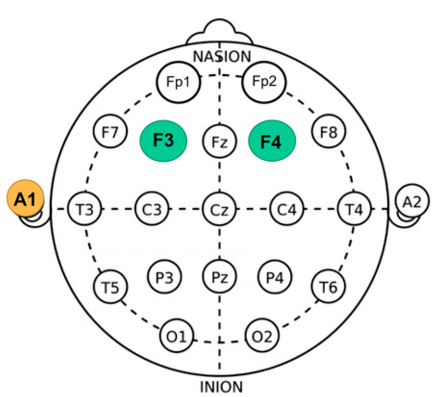

Fig. 2. International arrangement of the 10-20 electrode system (Jasper 1958).

Table 3. Results of relative alpha (RA), relative fast alpha (RFA), relative beta (RB), and relative low beta (RLB) spectrum according to electroencephalography results of 10 care farming activities.

Variable	RA[i]		RFA[ii]		RB[iii]		RLB[iv]	
	F3[v]	F4[vi]	F3	F4	F3	F4	F3	F4
	Mean ± *SD*							
Resting	0.183 ± 0.049	0.186 ± 0.046	0.059 ± 0.012	0.060 ± 0.013	0.334 ± 0.033	0.331 ± 0.031	0.073 ± 0.008	0.073 ± 0.009
Organizing a garden plot	0.196 ± 0.044	0.200 ± 0.032	0.068 ± 0.015	0.068 ± 0.010	0.306 ± 0.040	0.290 ± 0.036	0.093 ± 0.021	0.088 ± 0.011
Transplanting plants	0.194 ± 0.034	0.199 ± 0.040	0.068 ± 0.009	0.070 ± 0.009	0.311 ± 0.035	0.309 ± 0.049	0.090 ± 0.009	0.090 ± 0.012
Harvesting	0.173 ± 0.023	0.182 ± 0.030	0.061 ± 0.009	0.062 ± 0.010	0.323 ± 0.028	0.307 ± 0.036	0.082 ± 0.010	0.082 ± 0.011
Cooking using harvests	0.160 ± 0.028	0.165 ± 0.023	0.056 ± 0.008	0.058 ± 0.008	0.322 ± 0.031	0.324 ± 0.030	0.073 ± 0.010	0.076 ± 0.011
Creating art with natural objects	0.194 ± 0.040	0.189 ± 0.041	0.068 ± 0.014	0.066 ± 0.013	0.321 ± 0.042	0.312 ± 0.053	0.094 ± 0.016	0.092 ± 0.017
Interacting with a dog	0.159 ± 0.030	0.168 ± 0.037	0.057 ± 0.009	0.059 ± 0.009	0.350 ± 0.034	0.341 ± 0.046	0.081 ± 0.011	0.080 ± 0.011
Walking with a dog	0.199 ± 0.036	0.198 ± 0.037	0.066 ± 0.013	0.068 ± 0.011	0.294 ± 0.028	0.301 ± 0.028	0.087 ± 0.014	0.088 ± 0.012
Feeding rabbits	0.177 ± 0.041	0.171 ± 0.030	0.061 ± 0.013	0.060 ± 0.009	0.304 ± 0.041	0.307 ± 0.043	0.080 ± 0.013	0.080 ± 0.010
Cleaning up the farm	0.185 ± 0.035	0.190 ± 0.045	0.064 ± 0.009	0.065 ± 0.009	0.307 ± 0.063	0.308 ± 0.067	0.083 ± 0.010	0.082 ± 0.008
Maintaining a garden	0.157 ± 0.030	0.166 ± 0.036	0.058 ± 0.013	0.060 ± 0.014	0.331 ± 0.030	0.328 ± 0.031	0.079 ± 0.015	0.081 ± 0.016
Significance[vii]	0.000***	0.002**	0.000***	0.001**	0.000***	0.008**	0.000***	0.000***

[i] RA was calculated as follows: [alpha (8–13 Hz) power]/[total frequency (4–50 Hz) power].
[ii] RFA was calculated as follows: (fast alpha [11–13 Hz] power)/(total frequency [4–50 Hz] power).
[iii] RB was calculated as follows: (beta [12–30 Hz] power)/(total frequency [4–50 Hz] power).
[iv] RLB was calculated as follow: [low beta (12–15 Hz) power]/[total frequency (4–50 Hz) power].
[v] F3 = left frontal channel.
[vi] F4 = right frontal channel.
[vii] Statistical significance was determined using the Kruskal–Wallis test. ** and *** indicate significance at $P < 0.01$ and 0.001, respectively.

to represent and generate mental, emotional, internal, and motor-related behaviors (Fuster 2015), and it is involved in many aspects of stress, such as controlling the stress response (Buchanan et al. 2010).

We used the Bio-scan analysis program (Bio-tech, Daejeon, South Korea) to measure and analyze the EEG data. A power spectrum analysis was performed to identify the relative alpha (RA), relative fast alpha (RFA), relative beta (RB), and relative low beta (RLB) power spectra, as well as the spectral edge frequency 50 (SEF50) and spectral edge frequency as 50% of alpha (ASEF50). These parameters represent the different activation states of the frontal cortex (Table 2).

To measure subjective emotional states according to the activities, the POMS Short Form (POMS-SF) and SDM were used. The POMS-SF was developed by McNair et al. (2003). It consists of the following 30 items that describe feelings and moods: "Tension and Anxiety (T-A)," "Depression (D)," "Anger and Hostility (A-H)," "Vigor (V)," "Fatigue (F)," and "Confusion (C)." The participants responded using a 5-point Likert scale (range: 0, not at all; 4, extremely). Each of the six mood states was defined by five adjective items, and the total mood disorder (TMD) score was evaluated using the following formula: [(T-A) + (D) + (A-H) + (F) + (C) - (V)]. The lower the TMD score, the better the psychological state of the participant (Baker et al. 2002).

The SDM is a questionnaire that was developed by Osgood et al. (1957) to evaluate subjective emotional states. This questionnaire includes the following three states: "comfortable–uncomfortable," "natural–artificial," and "relaxed–awakening." Additionally, it uses a 13-point Likert-type scale ranging from −6 to 6. The higher the score for each item, the better the emotional condition.

Statistical analysis. To compare the frontal cortex activity and emotional state data according to each activity, the Kruskal–Wallis test was performed using SPSS (version 25 for Windows; IBM, Armonk, NY, USA); $P < 0.05$ was considered statistically significant. To analyze demographic information such as the age, height, weight, and body mass index of participants, Microsoft Excel (Office 2007; Microsoft Corp., Redmond, WA, USA) was used to generate descriptive statistics of the mean and *SD*.

Results

Demographic characteristics. Twenty participants 31.30 ± 9.76 years of age participated in the experiment; there were 7 male participants (age, 28.86 ± 8.03 years) and 13 female participants (age, 32.62 ± 10.63 years) (Table 1). The average body mass index was 21.90 ± 5.45 $kg \cdot m^{-2}$, which was within the range of the specified criteria for normal.

Electroencephalography. Significant differences were observed in the RA, RFA, RB, and RLB values of the frontal lobe according to care farming activities (Table 3). The RFA value increased in the frontal lobe when organizing a garden plot, transplanting plants, and creating art with natural object activities com-

Table 4. Results of spectral edge frequency 50% of the total spectrum band (SEF50) and spectral edge frequency 50% of alpha (ASEF50) according to the electroencephalography results of 10 care farming activities.

Variable	SEF50[i] F3[iii]	SEF50[i] F4[iv]	ASEF50[ii] F3	ASEF50[ii] F4
	Mean ± *SD*			
Resting	16.730 ± 3.390	16.619 ± 2.886	10.231 ± 0.225	10.225 ± 0.221
Organizing a garden plot	14.522 ± 4.487	13.202 ± 3.714	10.244 ± 0.222	10.164 ± 0.172
Transplanting plants	14.738 ± 4.317	14.484 ± 4.072	10.237 ± 0.256	10.265 ± 0.242
Harvesting	15.707 ± 2.700	14.315 ± 3.296	10.233 ± 0.212	10.198 ± 0.215
Cooking using harvests	17.537 ± 4.484	16.866 ± 3.849	10.218 ± 0.188	10.242 ± 0.127
Creating art with natural objects	14.675 ± 4.240	14.610 ± 4.487	10.250 ± 0.238	10.236 ± 0.264
Interacting with a dog	18.484 ± 4.489	17.727 ± 4.167	10.315 ± 0.193	10.313 ± 0.169
Walking with a dog	13.079 ± 3.438	13.527 ± 3.088	10.109 ± 0.180	10.196 ± 0.145
Feeding rabbits	15.840 ± 4.885	15.304 ± 4.037	10.216 ± 0.174	10.229 ± 0.172
Cleaning up the farm	14.605 ± 4.564	14.540 ± 4.643	10.254 ± 0.237	10.253 ± 0.266
Maintaining a garden	18.093 ± 4.878	17.202 ± 4.589	10.310 ± 0.232	10.306 ± 0.214
Significance[v]	0.000***	0.001**	0.323[NS]	0.563[NS]

[i] SEF50 is the frequency below which 50% of the total spectral power (4–50 Hz) resides.
[ii] ASEF50 is the frequency below which 50% of alpha spectral power (8–13 Hz) resides.
[iii] F3 = left frontal channel.
[iv] F4 = right frontal channel.
[v] Statistical significance was determined using the Kruskal–Wallis test.
NS, **, *** indicate nonsignificant and significance at $P < 0.01$ and 0.001, respectively.

Table 5. Emotional states according to the profile of mood states (POMS) based on 10 care farming activities.

Variable	V	D	C	T-A	A-H	F	TMD
	Mean ± *SD*						
Resting	4.80 ± 4.95	0.70 ± 1.95	2.10 ± 2.31	1.45 ± 2.24	0.40 ± 0.99	3.00 ± 3.32	2.85 ± 8.90
Organizing a garden plot	8.95 ± 4.86	0.65 ± 2.23	2.40 ± 2.23	0.90 ± 2.36	0.65 ± 2.23	2.40 ± 2.70	−1.95 ± 11.36
Transplanting plants	8.35 ± 4.60	0.60 ± 1.60	2.05 ± 2.48	0.90 ± 2.29	0.55 ± 2.24	1.95 ± 3.19	−2.30 ± 10.82
Harvesting	7.05 ± 5.04	0.40 ± 1.35	1.90 ± 2.15	0.55 ± 1.61	0.90 ± 1.74	1.50 ± 2.09	−1.80 ± 7.06
Cooking using harvests	8.00 ± 4.96	0.20 ± 0.52	1.75 ± 2.00	0.50 ± 1.61	0.15 ± 0.67	0.75 ± 1.25	−4.65 ± 5.67
Creating art with natural objects	8.55 ± 4.75	0.25 ± 0.72	2.35 ± 1.84	0.65 ± 1.04	0.25 ± 0.72	0.95 ± 1.70	−4.10 ± 4.70
Interacting with a dog	7.40 ± 4.94	0.10 ± 0.45	1.70 ± 1.63	1.35 ± 2.41	0.20 ± 0.89	0.55 ± 1.10	−3.50 ± 6.16
Walking with a dog	9.35 ± 5.35	0.05 ± 0.22	1.85 ± 1.46	0.85 ± 0.99	0.10 ± 0.31	1.15 ± 1.95	−5.35 ± 5.82
Feeding rabbits	7.85 ± 4.03	0.35 ± 0.99	2.25 ± 2.02	0.75 ± 1.33	0.20 ± 0.52	1.10 ± 1.45	−3.20 ± 5.86
Cleaning up the farm	5.25 ± 5.52	0.55 ± 1.32	1.45 ± 1.39	0.45 ± 1.15	0.75 ± 1.37	1.85 ± 2.13	−0.20 ± 5.43
Maintaining a garden	5.60 ± 5.27	0.55 ± 1.23	1.70 ± 2.18	0.55 ± 1.00	0.75 ± 1.48	1.35 ± 1.50	−0.70 ± 6.34
Significance[i]	0.010*	0.748[NS]	0.753[NS]	0.245[NS]	0.190[NS]	0.022*	0.003**

[i] Statistical significance was determined using the Kruskal–Wallis test. NS, *, ** indicate nonsignificant and significance at $P < 0.05$ and 0.01, respectively.
A-H = anger and hostility; C = confusion; D = depression; F = fatigue; T-A, tension and anxiety; V = vigor. Total score range: 0 to 20.
TMD = total mood disturbance. Total score range: −20 to 100. A lower score indicates a positive emotional state.

pared with that observed during other activities ($P < 0.01$). Similarly, the RLB value also increased when organizing a garden plot, transplanting plants, and creating art with natural objects and decreased during rest ($P < 0.001$). The RA and RB values significantly increased in the frontal lobe during animal-mediated activities, such as walking and interacting with a dog ($P < 0.01$).

The SEF50 in the frontal lobe exhibited significant differences after care farming activities (Table 4). In the frontal lobe, the SEF50 was higher during interaction with a dog and maintaining a garden than it was during other activities ($P < 0.01$). No significant differences were observed in the ASEF50 values according to activity ($P > 0.05$).

Profile of mood states and semantic differential method. The POMS results revealed significant differences in vigor, fatigue, and TMD scores of care farming activities (Table 5). Among the care farming activities, participants felt the most vigor while walking with a dog and the least vigor during rest ($P < 0.05$). The fatigue mood score was significantly higher when interacting with a dog than it was during other activities ($P < 0.05$). The TMD scores during rest were higher than those during care farming activities ($P < 0.01$), indicating that the participants had a more positive emotional state during care farming activities. Among the care farm activities, the TMD scores for walking with a dog and cooking using harvests were lower than those for other activities, indicating a positive mood state.

As presented in Fig. 3, the SDM results revealed significant differences in all items of comfort, naturalness, and relaxation according to care farming activities ($P < 0.01$). For all items, participants had the lowest scores during rest, implying that care farming activities induced more positive emotional states than rest. For each item, the participants responded that they were most comfortable during cooking using harvests and creating art activities (Fig. 3A), most natural during creating art and feeding activities (Fig. 3B), and most relaxed while creating art and interacting with a dog (Fig. 3C).

Discussion

We investigated the psychophysiological effects of care farming activities using frontal EEG and subjective questionnaires. The EEG results of each care farming activity revealed various changes in frontal cortex activity. In particular, activities involving plants, such as organizing a garden plot and transplanting plants, increased RFA and RLB (Table 3). Activities involving animals, such as interacting and walking with a dog, increased RA, RB, and SEF50 (Tables 3 and 4). According to the subjective POMS and SDM questionnaires, compared to resting, care farm activities induced positive emotional states. In particular, activities of creating art, walking, and interacting with a dog reduced negative emotional responses and increased positive emotional responses more than other care farming activities (Table 5 and Fig. 3).

Alpha and beta rhythms according to EEG represent the awake state (Rechtschaffen and Kales 1986) and have different characteristics depending on the frequency band.

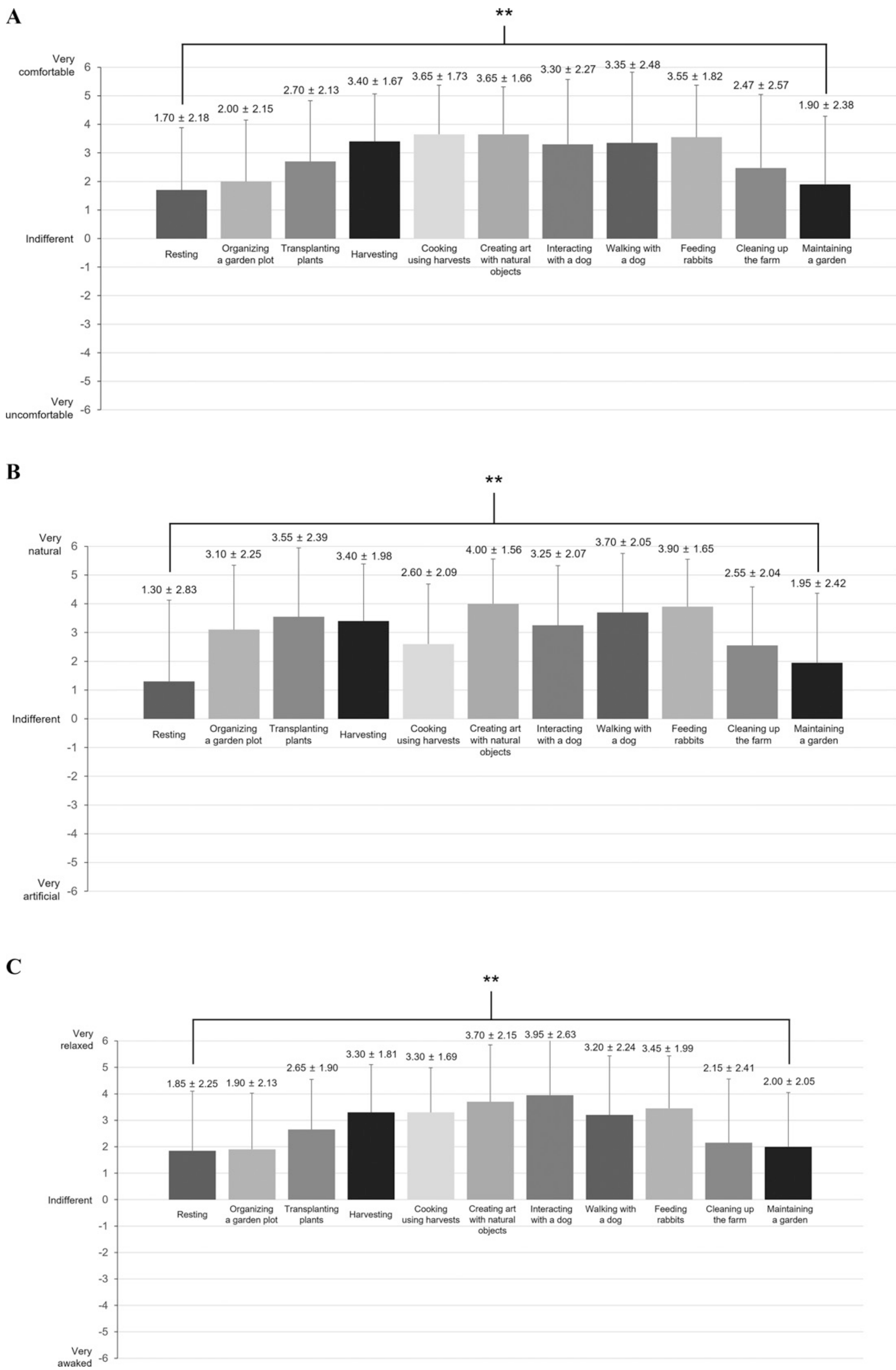

Fig. 3. Comparison of the semantic differential method (SDM) results of each care farming activity of adults (n = 20). Data are presented as the mean (M) ± *SD*: (**A**) being comfortable, (**B**) being natural, and (**C**) being relaxed.

Alpha rhythms ranging from 8 to 13 Hz are associated with relaxation, readiness, mental coordination, and peacefulness (Başar 2012; Kim et al. 2013), and fast alpha rhythms ranging from 11 to 13 Hz indicate optimal cognitive performance in the brain (Marzbani et al. 2016). We observed that RA and RFA values were high when organizing garden plots, transplanting plants, and walking with a dog. Previous studies have reported that increased cortical alpha activity can effectively reduce stress and anxiety (Budzynski 2009; Moore 2000; Vernon 2005), and that increased fast alpha activity stabilizes emotional anxiety and allows brain activation (Choi et al. 2012). Olszewska-Guizzo et al. (2020) reported brain activity patterns in healthy adults suggestive of relaxation and positive emotions during passive exposure to therapeutic gardens. Contact with nature reduces human stress (Hartig et al. 1997; Kaplan and Kaplan 1989), and active intervention with natural resources, such as agricultural activities, can maximize this effect by stimulating the senses of touch, smell, and taste (Lin et al. 2014).

Beta rhythms ranging from 12 to 30 Hz are generally associated with sustained attention, tension, alertness, excitement, and thinking (Gomez et al. 1998; Kristeva-Feige et al. 2002; Vázquez Marrufo et al. 2001). In particular, the low beta rhythm ranges from 12 to 15 Hz and is called the sensory-motor rhythm, which is related to cognitive functions, such as concentration (Bakhtadze et al. 2016) and complex psychomotor skills (Doppelmayr and Weber 2011; Ros et al. 2009). In our study, care farming activities exhibited higher RLB values than resting; among them, crafting art with natural objects and gardening activities (organizing garden plots and transplanting plants) exhibited higher values than other activities. A previous study also reported that horticultural activities, such as washing leaves and transplanting plants, positively affect cognitive activity by increasing the RLB in the prefrontal cortex of older adults (Kim et al. 2021). Additionally, the crafting art activity conducted in this study is believed to have increased the RLB value because it is a complex psychomotor activity that uses fine motor movements, including selecting and arranging small natural objects in creative designs. Low beta rhythms reduce anger, stress, and anxiety (Egner and Gruzelier 2004; Vernon 2005); therefore, participation in care farming activities can have positive effects on the cognitive and emotional aspects of adults.

The RB value was significantly higher during interaction with a dog than it was during other care farming activities. A similar study reported that animal-assisted therapy with dogs increased the beta EEG activity in children who underwent surgical procedures (Calcaterra et al. 2015). Activities involving animals are a form of multimodal sensory stimulation that provide humans with social interaction and attachment (Kurdek 2009), attract attention, and lead to spontaneous affectionate responses (Borgi and Cirulli 2016). In this study, the active interaction with a dog was considered a dynamic stimulus that raised the consciousness of participants, and this stimulus increased beta activity in the frontal lobe. Similarly, interaction with a dog resulted in the highest SEF50 value compared with those of the other activities. The SEF50 is an indicator that increases as the higher-frequency band is activated among the total frequency (4–50 Hz) bands and is commonly considered an indicator of brain arousal (Schwarz et al. 2004). An increased SEF50 indicates increased cerebral cortical activity (Yu et al. 2012), which is also believed to originate from actively interacting with a dog. Interventions that increase the activity of the beta band have been used to improve individual attention and cognitive ability (Staufenbiel et al. 2014), and the results of this study suggest that continuous participation in care farming activities may have a positive effect on cognitive aspects.

According to the POMS results, the participants responded that they felt the most vigorous when walking with a dog, and the associated TMD score was also the lowest. A previous study also reported that walking with a dog induced a positive emotional state, with a TMD score of -4.9 ± 2.8 to -1.0 ± 1.7 (Covington et al. 2021). Compared with the TMD score range of horticultural activities measured during previous studies (Kim et al. 2021; Lee et al. 2021), the care farming activities in this study had similar or lower scores. Unlike the horticultural activities conducted indoors or in an urban garden environment during those studies, the activities conducted on an actual care farm during this study had more positive effects on the subjective emotional state of the participants. Cohen (1978) reported that, compared with urban environments, exposure to natural environments achieves psychological recovery, and related studies also reported that green environments have psychophysiological benefits, such as stabilizing the autonomic nervous system and increasing cerebral alpha activity (Jiang et al. 2019; Lee et al. 2011).

Based on the SDM results, significant differences were observed between the care farming activities. The participants responded that they felt most natural and comfortable when crafting art using natural objects. Traditionally, crafts have been used during art therapy (Belkofer et al. 2014; Kruk et al. 2014), and some studies have demonstrated that craft activities could be a type of "natural antidepressant," especially for those experiencing depression and anxiety-related issues (Geda et al. 2011; Riley et al. 2013). Craft activities are not limited to materials, especially those that use natural objects, such as branches, pine cones, and fallen leaves, which allow participants to feel a sense of nature and pleasantness. The product completed through craft activities contributes to the happiness of participants by providing them with a purpose and sense of accomplishment (Kenning 2015). Participants also responded that they felt most natural when interacting with a dog. Menna et al. (2019) reported that animal-assisted activities with dogs induce the release of oxytocin and serotonin from the blood of patients with end-stage renal disease. Odendaal (2000) reported increased β-endorphin, oxytocin, prolactin, phenylacetic acid (a metabolite of β-phenylethylamine), and dopamine levels and decreased cortisol levels in participants after interaction with a dog. Wilson (1991) reported that positive interactions between humans and animals relieve anxiety and stress and stabilize the autonomic nervous system. Animals provide a sense of safety and comfort by providing a pleasurable external focus for human attention, which can reduce sympathetic nervous system arousal (Odendaal 2000). During this study, walking with a dog on the farm led to positive interactions and psychological stability in the participants.

During this study, we evaluated the frontal cortex activity and subjective emotional state based on the activities of a program conducted at an actual care farm and collected the basic data necessary for developing a care farming program to improve the mental health of adults. This study significantly contributes to the literature because data regarding frontal cortical activities during agricultural activities conducted using various farm resources are limited. In the future, from the perspective of preventive medicine, it is necessary to develop and disseminate care farming programs that align with the individual goals of participants and promote mental health.

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