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Impact of Agro-healing Activities on Adult Brain Activity Measured by EEG

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Abstract. **This study investigated electroencephalogram (EEG)-based psychophysiological responses to agro-healing activities in adults. Eighteen participants in Cheongju, South Korea, each completed seven activities—raking, planting, harvesting, cleaning (weeding and sweeping), cooking, dog brushing, and painting—for 5 minutes, with 10-minute rest intervals between randomized tasks. Brain waves were continuously recorded, and relative alpha (RA), relative beta (RB), relative gamma (RM), relative fast alpha (RFA), relative low beta (RLB), and ASEF50 (spectral edge frequency 50% of alpha) were calculated. Within the results, raking, planting, harvesting, and cleaning showed significant increases in RA compared with baseline ($P < 0.05$), indicating enhanced relaxation. Raking, planting, harvesting, painting, and cleaning significantly increased ASEF50 ($P < 0.05$), reflecting greater comfort and emotional stability. Raking, planting, and harvesting also showed significant activation in RFA and RLB ($P < 0.05$), indices associated with learning, attentional processing, and sustained vigilance. In contrast, cooking, dog brushing, and painting produced significant increases in RB ($P < 0.05$), indicative of an alert and aroused state, and in RM ($P < 0.05$), which is related to memory, learning, and selective attention. Overall, raking, planting, and harvesting elicited the broadest pattern of beneficial activation across relaxation (RA), attention and learning (RFA, RLB), and emotional stability (ASEF50), whereas cleaning primarily supported attention and stability. These findings demonstrate that specific agro-healing activities differentially modulate neural indices of relaxation, arousal, attention, and cognition in adults, providing an empirical basis for designing personalized agro-healing programs tailored to targeted cognitive and emotional outcomes.**

In modern society, rising stress, mental health challenges, and social isolation have heightened interest in the therapeutic use of agriculture. Internationally, this interest has taken different institutional forms. In Europe, services are often organized as care farms and broader social farming programs—farms that host health, education, or social-inclusion services for specific client groups (Cacciatore et al. 2020). Loue (2016) defined care farms as expert-led services using rural resources to promote health and recovery, and Torquati et al. (2019) reported that participation in care farming improved both agricultural skills and psychological well-being among individuals with autism spectrum disorder. In South Korea, these practices are framed as agro-healing, referring to structured, expert-led interventions—defined and supported by national policy—that leverage agricultural and rural resources to promote psychological, social, cognitive, and physical health (Gim et al. 2013; Kim et al. 2016). Although the precise historical origins of agro-healing in France and Flanders (Belgium) are difficult to trace, agro-healing and related practices have become key components of social solidarity initiatives. Across European and Korean contexts, empirical studies consistently show that participation in agricultural activities is associated with reduced stress, improved psychological well-being, and favorable changes in selected physical health indicators in both general and vulnerable populations (Braastad and Hauge 2007; Iommi 2005; Jang et al. 2021; Jeong et al. 2019; Kim et al. 2012; Park and Kang 2017; Park and Park 2024; Son and Park 2025; Schaik 1997).

Collectively, this literature defines agro-healing as a holistic, evidence-informed intervention that uses agricultural and rural environments—such as plants, animals, forests, and landscapes—to promote physical and psychological health across diverse populations. However, despite accumulating reports of beneficial outcomes, relatively few investigations have addressed the underlying physiological mechanisms, particularly the neural processes through which agricultural activities influence emotion and cognition (Relf 2006; Rural Development Administration 2018). Establishing objective, neurophysiological indicators of these effects has therefore become an important research priority. In this context, electroencephalography (EEG) offers a sensitive tool for quantifying psychophysiological responses during naturalistic tasks: alpha activity is typically associated with relaxation and stress reduction, beta with alertness and cognitive engagement, and gamma with learning and memory integration, whereas frontal, parietal, and temporal regions differentially support executive control, emotion regulation, attention, and memory (Cabeza and Nyberg 2000; Gazzaniga et al. 2002; Marchand 2014; Tanida et al. 2004; Tomasino and Rumiati 2013).

Previous EEG work in therapeutic horticulture has mainly focused on muscle activity, physical intensity, and activation of the prefrontal and frontal cortices during

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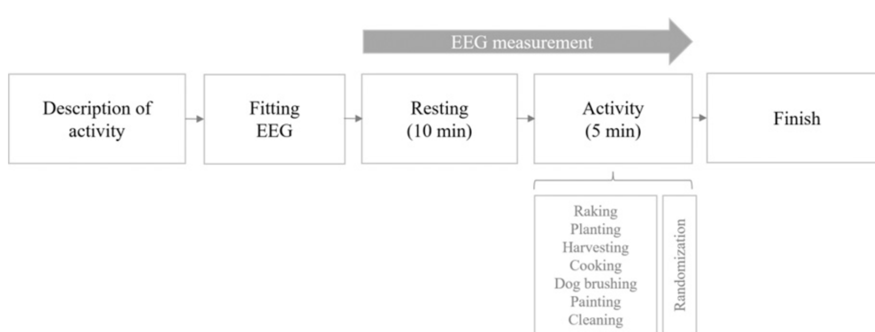
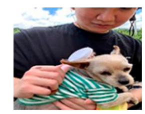
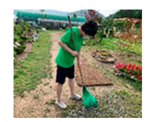


Fig. 1. Description of activities: Perform each activity for 5 min, rest for 10 min between activities. EEG = electroencephalogram.

Table 1. Detailed description of the seven agro-healing activities and their environmental settings.

Activity classification	Agro-healing activities		
Horticultural activities	Raking	1. Digging the soil with a shovel in a 6.6-m^2 garden. 2. Leveling the soil. 3. Digging furrows.	
	Planting	1. Using a hoe to dig holes in the soil to plant pepper and lettuce seedlings in a 3.3-m^2 garden. 2. Covering and tamping down each seedling with soil. 3. Watering. 4. Repeating until all five pepper seedlings and five lettuce seedlings were planted.	
	Harvesting	1. Carrying a harvesting basket. 2. Moving to the 6.6-m^2 vegetable garden. 3. Harvesting lettuce. 4. Moving 50-m from the vegetable garden to the orchard. 5. Harvesting barley berries in the 33-m^2 orchard.	
	Cooking	1. Washing and cutting the harvested lettuce in the kitchenette next to the garden. 2. In the kitchen, I put a bowl of rice in a bowl, added chopped lettuce and gochujang, and mixed it with my spoon to complete the bibimbap.	
Animal-assisted activities	Dog brushing	1. Sit down on a shaded outdoor chair holding my dog (a Maltese). 2. Make eye contact with the dog and greet it. 3. Briefly hold and pet the dog. 4. Brush the dog's fur.	
Other agricultural activities	Painting	1. Walk along the trail. 2. Pick up a 5-cm pebble. 3. Sit at an outdoor table. 4. Dust the pebble. 5. Paint using five colors of acrylic paint. 6. Let dry.	
	Cleaning (weeding and sweeping)	1. Organize my farm equipment. 2. Weed the 66-m^2 garden. 3. Sweep the area around the garden. 4. Throw away the collected trash and weeds.	

relatively constrained tasks (Lee et al. 2021; Morita et al. 2018), with limited attention to dynamic neural activation across multiple cortical regions in real farm environments. To address this gap, the present study employs mobile EEG to record brain activity from 12 cortical regions while adults perform actual agro-healing activities (e.g., sowing, weeding, harvesting) in situ. By examining how specific tasks modulate task-related brainwave patterns, this study seeks to clarify key psychophysiological mechanisms underlying agro-healing experiences and to provide preliminary neural evidence that may inform the refinement of future plant-mediated therapeutic programs for adults.

Materials and Methods

Participants. Participants were recruited by posting promotional materials on bulletin boards at apartment management offices, universities, and online agricultural activity community sites within 10 km of the care farm in Cheongju, South Korea. Eligibility criteria included adults aged 20–60 years who had no difficulty performing agricultural activities and voluntarily agreed to participate after receiving an explanation of the study's purpose and procedures. Eighteen individuals (mean age = 43.0 ± 12.6 years), all with prior agricultural experience and currently employed, took part in the experiment. To control for potential confounding factors, participants were instructed to abstain from caffeine intake within 3 hours before EEG recording and to perform all tasks using their dominant hand to maintain consistency across measurements. All experimental procedures were approved by the Institutional Review Board of Konkuk University (Project Number: 7001355-202204-HR-546) and were conducted in accordance with the ethical principles of the Declaration of Helsinki.

Agro-healing activities. The resources of the care farm were analyzed, and seven plant- and animal-based activities—such as digging, planting, watering, and harvesting—were selected as core therapeutic tasks (Lee et al. 2012; Park et al. 2014). The seven activities included digging, leveling, and making furrows in a 3.3-m^2 garden (i.e., raking); digging

Table 2. List of electroencephalogram electrode sites and corresponding brain regions analyzed in this study.

Brain region			Description
Prefrontal cortex (i.e., PFC)	Fp1	Fp2	Involved in higher-order cognitive control, including planning, decision making, working memory, attention regulation, and emotional regulation.
Frontal lobe	F3	F4	Associated with executive functions, working memory, selective attention, and planning and control of voluntary movement (premotor and supplementary motor areas).
Central lobe	C3	C4	Overlying primary motor and primary somatosensory cortices; involved in voluntary motor execution and processing of somatosensory and proprioceptive information.
Parietal lobe	P3	P4	Involved in integration of multisensory information, spatial attention, body awareness and proprioception, and aspects of numerical and language processing (particularly in the left hemisphere).
Temporal lobe	T3	T4	Involved in auditory processing; speech and language perception; verbal memory; and the recognition of objects, faces, and voices.
Occipital lobe	O3	O4	Primary and associative visual cortices; responsible for processing visual information such as form, color, and motion.

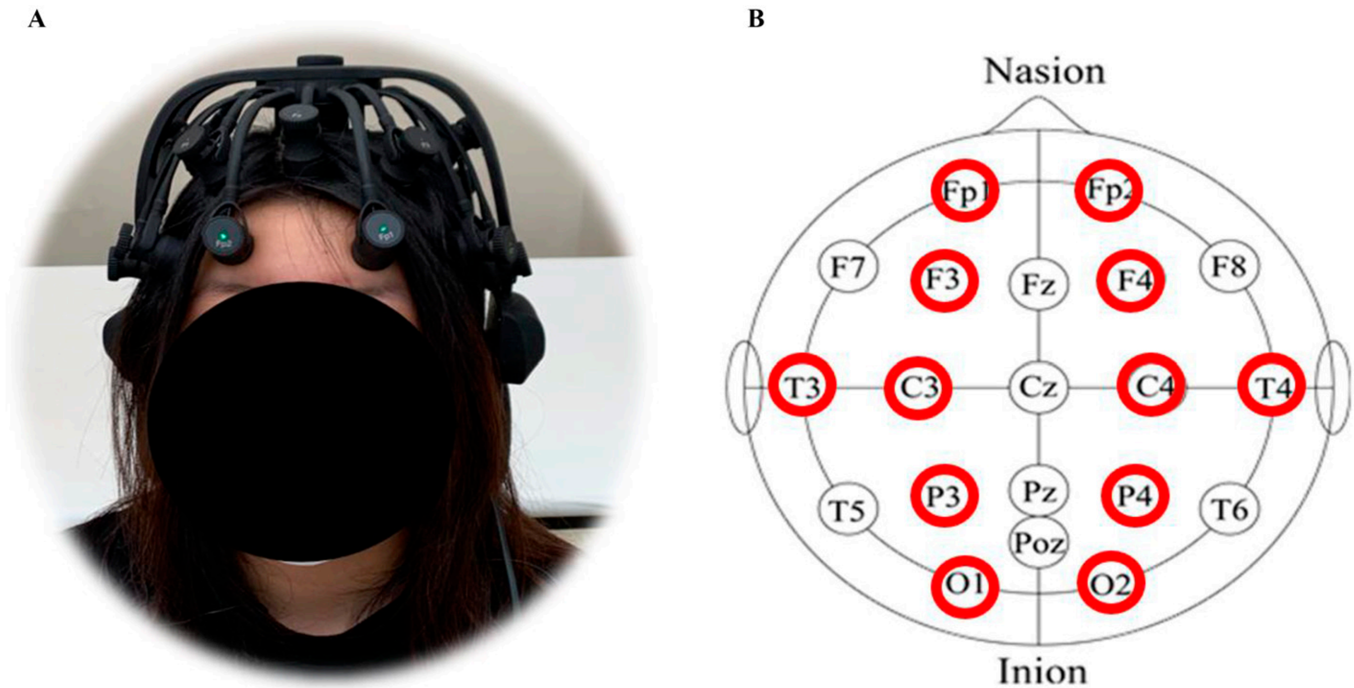


Fig. 2. Experimental performance appearance. (**A**) Wireless dry electroencephalogram device. (**B**) Measured brain areas: prefrontal cortex (Fp1, Fp2), frontal lobe (F3, F4), central lobe (C3, C4), parietal lobe (P3, P4), temporal lobe (T3, T4), occipital lobe (O3, O4).

holes in the ground by hoe to plant pepper and lettuce seedlings, planting them, and watering them (i.e., planting); harvesting lettuce in another 6.6-m^2 garden and barley berries in a 66-m^2 orchard (i.e., harvesting); washing and cutting the harvested lettuce and making bibimbap in a simple kitchen with a tap next to the vegetable garden (i.e., cooking). Other activities included sitting on a shaded outdoor chair holding a dog (a Maltese), making eye contact, greeting, and brushing it (dog brushing); dusting and painting gravel (5-cm in diameter) along the care farm path (i.e., painting); and tidying up the surrounding area including the 33-m^2 garden [i.e., cleaning (weeding and clearing)] (Table 1). Participants visited the care farm individually. Before the experimental session, they received instructions on precautions for wearing the EEG device and an explanation of the seven activities, and then practiced each activity twice. After the EEG device was fitted, participants rested quietly for 10 min, performed each activity for 5 min, and then rested for 10 min before proceeding to the next activity. The order of activities was counterbalanced across participants using a Latin square design to minimize order effects (Fig. 1).

Experimental environment. The care farm is located ~10 km from downtown Cheongju, South Korea, and covers an area of ~3305.79-m^2, surrounded by rice paddies, fields, and low mountains. Using the resources of the care farm, the site includes an empty vegetable garden, vegetable patch, orchard, herb garden, walking path, and indoor training center. The seven selected agro-healing activities were conducted in various settings, including an empty garden plot, orchard, vegetable garden,

Table 3. Selection of six neurophysiological indicators associated with attention, relaxation, focus, and memory.

Analysis indicators	The full name of the EEG power spectrum indicator	Wavelength range (Hz)	Typical functional interpretation
ASEF50	Spectral edge frequency 50% of alpha	8–13 (alpha band)	Often associated with comfortable, stable, and relaxed wakefulness
RA	Relative alpha	(8–13)/(4–50)	Typically associated with relaxation and a calm, wakeful state
RB	Relative beta	(13–30)/(4–50)	Often associated with alertness and active cognitive engagement
RG	Relative gama	(30–50)/(4–50)	Often associated with memory, learning, and selective attention
RFA	Relative fast alpha	(11–13)/(4–50)	Associated with relaxed concentration and creative or task-focused states
RLB	Relative low beta	(12–15)/(4–50)	Associated with sustained attention and vigilance

Table 4. Relative alpha (RA[i]) power across seven agro-healing activities.

Variable	F3	F4	C3	C4	T3	T4
Raking	0.20 ± 0.03 a	0.20 ± 0.04 a	0.21 ± 0.03 ab	0.22 ± 0.03 a	0.17 ± 0.03	0.18 ± 0.04 abc
Planting	0.21 ± 0.02 a	0.20 ± 0.02 a	0.20 ± 0.03 abc	0.20 ± 0.03 abc	0.17 ± 0.03	0.18 ± 0.04 ab
Harvesting	0.19 ± 0.02 ab	0.20 ± 0.03 a	0.22 ± 0.04 a	0.21 ± 0.02 ab	0.17 ± 0.03	0.19 ± 0.03 a
Cooking	0.17 ± 0.03 bc	0.17 ± 0.04 b	0.18 ± 0.04 bc	0.18 ± 0.05 bc	0.16 ± 0.04	0.17 ± 0.03 bc
Dog brushing	0.17 ± 0.04 bc	0.18 ± 0.03 ab	0.18 ± 0.03 c	0.18 ± 0.02 c	0.15 ± 0.03	0.16 ± 0.03 c
Painting	0.17 ± 0.03 c	0.18 ± 0.03 ab	0.18 ± 0.04 bc	0.18 ± 0.03 bc	0.15 ± 0.03	0.16 ± 0.03 bc
Cleaning (weeding and sweeping)	0.19 ± 0.03 ab	0.20 ± 0.03 a	0.20 ± 0.04 abc	0.20 ± 0.04 abc	0.17 ± 0.03	0.17 ± 0.03 bc
Significant	0.001**	0.033*	0.003**	0.004**	0.084^{NS}	0.033*

[i] RA power spectra were calculated by [alpha (8 to 13 Hz) po0.12wer]/[total frequency (4 to 50 Hz) power].
$_{NS}$ = nonsignificant; *, ** significantat $P < 0.05$ and $P < 0.001$, by one-way analysis of variance, respectively.
F3 = left frontal lobe; F4 = right frontal lobe; C3 = left central lobe; C4 = right central lobe; T3 = left temporal lobe; T4 = right temporal lobe.

Table 5. Relative beta (RB[i]) power across seven agro-healing activities.

	Fp1	Fp2	F3	F4
Variable	Mean ± standard deviation			
Raking	0.29 ± 0.04 abc	0.30 ± 0.04 abc	0.32 ± 0.05	0.32 ± 0.04 b
Planting	0.31 ± 0.04 ab	0.30 ± 0.04 ab	0.32 ± 0.04	0.32 ± 0.04 b
Harvesting	0.31 ± 0.06 ab	0.29 ± 0.04 bc	0.33 ± 0.06	0.32 ± 0.04 b
Cooking	0.29 ± 0.04 a	0.28 ± 0.04 a	0.32 ± 0.04	0.32 ± 0.03 a
Dog brushing	0.27 ± 0.04 c	0.27 ± 0.03 c	0.33 ± 0.04	0.32 ± 0.03 b
Painting	0.30 ± 0.03 bc	0.28 ± 0.03 bc	0.32 ± 0.04	0.33 ± 0.03 b
Cleaning (weeding and sweeping)	0.30 ± 0.04 bc	0.30 ± 0.03 ab	0.35 ± 0.06	0.31 ± 0.04 b
Significant	0.004**	0.002**	0.576[NS]	0.011*

[i] RB power spectra were calculated by [beta (13 to 30 Hz) power]/[total frequency (4 to 50 Hz) power].

NS = nonsignificant; *, **significant at $P < 0.05$ and $P < 0.01$ by one-way analysis of variance, respectively.

Post hoc analysis a > b > c according to Duncan's multiple range tests, Bonferroni.

Fp1 = left prefrontal lobe; Fp2 = right prefrontal lobe; F3 = left frontal lobe; F4 = right frontal lobe.

Table 6. Relative gamma (RG[i]) power across seven agro-healing activities.

	F3	F4	C3	C4	P3	P4
Variable	Mean ± standard deviation					
Raking	0.19 ± 0.06 b	0.20 ± 0.07 b	0.17 ± 0.05 d	0.17 ± 0.06 ab	0.25 ± 0.07 ab	0.23 ± 0.07
Planting	0.20 ± 0.05 b	0.20 ± 0.04 ab	0.18 ± 0.08 bcd	0.18 ± 0.07 ab	0.25 ± 0.08 ab	0.24 ± 0.09
Harvesting	0.20 ± 0.04 ab	0.19 ± 0.06 b	0.17 ± 0.08 d	0.17 ± 0.05 b	0.23 ± 0.07 b	0.23 ± 0.07
Cooking	0.25 ± 0.06 a	0.25 ± 0.08 a	0.25 ± 0.08 ab	0.25 ± 0.09 ab	0.29 ± 0.06 a	0.28 ± 0.08
Dog brushing	0.25 ± 0.07 a	0.22 ± 0.07 ab	0.24 ± 0.06 abc	0.24 ± 0.06 ab	0.28 ± 0.04 a	0.27 ± 0.06
Painting	0.25 ± 0.06 a	0.25 ± 0.07 a	0.27 ± 0.07 a	0.27 ± 0.06 a	0.30 ± 0.04 a	0.30 ± 0.04
Cleaning (weeding and sweeping)	0.21 ± 0.08 ab	0.19 ± 0.08 b	0.20 ± 0.09 cd	0.20 ± 0.10 ab	0.25 ± 0.08 ab	0.25 ± 0.09
Significant	0.011*	0.014*	0.002**	0.000***	0.031*	0.050[NS]

[i] RA power spectra were calculated by [gamma (30 to 50 Hz) power]/[total frequency (4 to 50 Hz) power].

NS = nonsignificant; *, **, *** significant at $P < 0.05$, $P < 0.01$, and $P < 0.001$ by one-way analysis of variance, respectively.

Post hoc analysis a > b > c according to Duncan's multiple range tests, Bonferroni.

F3 = left frontal lobe; F4 = right frontal lobe; C3 = left central lobe; C4 = right central lobe; P3 = left parietal lobe; P4 = right parietal lobe.

outdoor kitchen, and an open space with garden beds. Activities were implemented from Jul to Aug 2022, during the summer season, and were suspended on rainy days.

The environmental conditions of each experimental session were carefully documented and maintained to ensure consistency across activities. The average ambient temperature was 29.3 ± 3.4 °C, and the average relative humidity was 60.1% ± 13.2% during the experimental period. To prevent dehydration or heat-related stress during outdoor activities, participants were allowed to take sufficient rest indoors when necessary. Ambient temperature, light intensity, and noise levels were monitored to minimize external influences on EEG recordings.

Measurement. EEG measures the electrical activity of the brain. EEG data were recorded using a wireless 20-channel system (Quick-20; Cognionics, San Diego, CA, USA) equipped with active dry electrodes. The system incorporates hardware-level shielding and a driven-right-leg circuit to minimize common-mode noise and electromagnetic interference, while high-impedance active electrodes reduce motion-related artifacts. Owing to its wireless design and lightweight active shielding, the Quick-20 allows for high-quality EEG acquisition even during moderate body movement or naturalistic activities (Lee et al. 2021), making it suitable for field-based experiments such as agro-healing tasks conducted outdoors. Raw signals were band-pass filtered (0.5–45 Hz) with a 60-Hz notch filter to remove power-line noise. Ocular and muscular artifacts were identified and removed using independent component analysis and automatic subspace reconstruction. All signals were re-referenced to the averaged mastoids to enhance the signal-to-noise ratio.

Data were obtained as averaged EEG values during each experimental task using a brain-mapping program (Bioteck Analysis; Bio-Tech, Daejeon, South Korea). A total of 20 electrodes were attached, including the left prefrontal cortex (Fp1), right prefrontal cortex (Fp2), left frontal lobe (F3), and right frontal lobe (F4). In this study, we analyzed the prefrontal, frontal, occipital, and temporal cortices, which are associated with cognitive functions such as memory, attention, and emotional processing (Banich et al. 2008; Miller & Cohen 2001) (Table 2; Fig. 2).

Brain waves are electrical signals that indicate the state of the brain's neural function in the cerebral cortex (Min and Park 1980) and are a useful source of information for interpreting and analyzing human thoughts and emotions (Kim et al. 2016). Brain waves from the cerebral cortex are classified into theta waves (4–8 Hz), alpha waves (8–13 Hz), beta waves (13–30 Hz), and gamma waves (30–50 Hz), each of which represents a specific physiological function (Sowndhararajan et al. 2015). Theta waves are observed during shallow sleep, alpha waves are observed during relaxation and muscle relaxation, and beta waves are observed during arousal and mental activity (Marzbani et al. 2016). In this study, six EEG indices related to attention, relaxation, concentration, and memory were selected. Specifically, ASEF50 (Spectral Edge Frequency 50% of alpha) was used to represent comfort and emotional stability of the brain, and RA power spectrum was selected as an

Table 7. Spectral edge frequency 50% (ASEF50[i]) of the alpha band across seven agro-healing activities.

	Fp1	Fp2
Variable	Mean ± standard deviation	
Raking	10.11 ± 0.23 a	10.16 ± 0.16 ab
Planting	10.18 ± 0.20 a	10.24 ± 0.23 a
Harvesting	10.16 ± 0.15 a	10.08 ± 0.16 bc
Cooking	9.96 ± 0.25 a	10.02 ± 0.20 c
Dog brushing	10.10 ± 0.18 b	10.02 ± 0.08 c
Painting	10.17 ± 0.16 a	10.06 ± 0.16 bc
Cleaning (weeding and sweeping)	10.17 ± 0.12 a	10.14 ± 0.24 abc
Significant	0.014*	0.004**

[i] ASEF50 power spectra were calculated by [alpha (8 to 13 Hz) power]/[total frequency (4 to 50 Hz) power].

*, ** significant at $P < 0.05$ and $P < 0.01$ by one-way analysis of variance, respectively.

Post hoc analysis a > b > c according to Duncan's multiple range tests, Bonferroni.

Fp1 = left prefrontal lobe; Fp2 = right prefrontal lobe.

indicator of relaxation. RB was associated with decision making, logical reasoning, and problem solving, and RG reflected a state of deep concentration and cognitive integration. The RLB power spectrum, a subcomponent of beta activity, has been reported to increase during problem solving and analytical thinking (Jang et al. 2014). Additionally, the RFA power spectrum was included to capture memory-related and attentional processing, as fast alpha activity has been linked to active cognitive engagement and learning efficiency (Bazanova and Vernon 2014; Klimesch 1999) (Table 3).

Data analysis. EEG analysis was conducted using IBM SPSS Statistics for Windows (Version 25; IBM Corp., Armonk, NY, USA). The normality of the data was verified using the Shapiro-Wilk test, and the results indicated that the assumption of normality was satisfied ($P > 0.05$). Levene's test for homogeneity of variances was also nonsignificant ($P > 0.05$), confirming that the assumption of homogeneity was met. One-way analysis of variance was followed by post hoc tests and Duncan's multiple range test. All significance levels were set at $P < 0.05$. Demographic information was analyzed using Microsoft Excel (Microsoft Office 365 ProPlus, Microsoft, Redmond, WA, USA) to obtain descriptive statistics for gender and age.

Result

Brain response through electroencephalography. Significant differences in RA were observed across several brain regions depending on the type of agro-healing activity (Table 4). During raking, significant difference was found in F3, F4, and C4 ($P < .01$) as well as P3 ($P < 0.05$). During planting, F3 and F4 showed significant activation ($P < 0.01$). During harvesting, F4 ($P < 0.05$), C3, and T4 ($P < 0.01$) exhibited significant changes. In cleaning (weeding and sweeping), significant activation was observed in F4 ($P < 0.01$) and P3 ($P < 0.05$).

During cooking, significant differences in RB were observed in Fp1 and Fp2 ($P < 0.01$) and F4 ($P < 0.05$) (Table 5).

Significant differences in RG were observed during cooking at F3 and F4 ($P < 0.05$); dog brushing at F3 and P3 ($P < 0.05$); and painting at F3, F4 ($P < 0.05$), C3, C4 ($P < 0.01$), and P3 ($P < 0.05$) (Table 6).

Significant differences in ASEF50 were observed at Fp1 during raking, planting, harvesting, cooking, painting, and cleaning (weeding and sweeping) ($P < 0.05$) and at Fp2 during planting ($P < 0.01$) (Table 7).

Significant differences in RFA were observed during raking at C4 and P3 ($P < 0.05$) and T3 ($P < 0.01$); during planting at Fp2, F3, P4, T3, and T4 ($P < 0.01$); and during harvesting at F4 ($P < 0.05$) and C3 ($P < 0.01$) (Table 8).

Significant differences in RLB were observed during raking at Fp1 ($P < 0.05$), Fp2 and F3 ($P < 0.001$), and O2 ($P < 0.01$); during planting at Fp1 ($P < 0.05$), Fp2 and F3 ($P < 0.001$), C4 ($P < 0.1$), P4 ($P < 0.001$), T3 ($P < 0.01$), T4 ($P < 0.05$), and O1 and O2 ($P < 0.01$); and during harvesting at F4, C3, P3, and T4 ($P < 0.05$), and O1 and O2 ($P < 0.01$) (Table 9).

Discussion

This study measured the psychophysiological responses of adults engaging in seven agro-healing activities—raking, planting, harvesting, cooking, dog brushing, painting, and cleaning (weeding and sweeping)—and explored their implications for cognitive and emotional functioning. The activation of ASEF50 in the Fp1 region observed in this study indicated enhanced comfort and emotional stability, consistent with previous findings showing that prefrontal cortex (PFC) activation supports planning, attention, and emotional regulation (Das and Giri 1979; Lee et al. 2021). As the PFC plays a central role in the pathophysiology of depression (Cheon 2013; Kang et al. 2018), these results may reflect neural processes associated with emotional stability and cognitive flexibility, rather than direct causal effects. By extending neural observation beyond the frontal cortex to 12 electrode sites, this study contributes to the neurophysiological evidence base for therapeutic agriculture and provides preliminary correlational data on its potential relevance to psychophysiological well-being.

Significant activation of RFA and RLB suggests a cognitive state characterized by sustained attention with relatively low cognitive load, consistent with mindfulness-related activation patterns reported in the frontal and parietal regions (Marchand 2014; Tomasino and Rumiati 2013). The frontal lobe is broadly involved in higher-order cognitive control, whereas the parietal lobe contributes to visuospatial and attentional processing (Brass and von Cramon 2002; Huettel et al. 2002). Concurrent changes in these regions therefore point to integrative cognitive engagement during task performance, rather than simple sensory or motor activation alone. Specifically, planting was accompanied by increased RFA and RLB together with frontal–parietal coactivation, a pattern that has often been observed during tasks requiring sustained attention and maintenance of task-relevant information, and may therefore reflect engagement of attentional and memory-related processes (Cabeza and Nyberg 2000; Kim and Park 2023).

During planting and harvesting, RLB changes also appeared in temporal and occipital regions. Given the roles of these areas in long-term memory retrieval, visual processing, and semantic integration, this broader distribution may be related to recalling prior planting or harvesting experiences, visually monitoring plant and soil conditions, and linking sensory input with task goals (Gazzaniga et al. 2002; Laeng and Teodorescu 2002; Mast and Kosslyn 2002). These interpretations are consistent with neuroimaging evidence that frontal and parietal regions contribute to attention and working memory, whereas temporal regions are more strongly involved in episodic recall (Cabeza and Nyberg 2000). In line with this,

Table 8. Relative fast alpha (RFA[i]) power spectrum across seven agro-healing activities.

Variable	Fp1	Fp2	F3	F4	C3	C4	P3	P4	T3	T4
Raking	0.06 ± 0.01	0.06 ± 0.01 ab	0.07 ± 0.01 ab	0.07 ± 0.01 ab	0.07 ± 0.02 ab	0.07 ± 0.01 a	0.07 ± 0.01 a	0.07 ± 0.01 ab	0.06 ± 0.01 a	0.06 ± 0.01 abc
Planting	0.06 ± 0.01	0.06 ± 0.01 a	0.07 ± 0.01 a	0.07 ± 0.01 abc	0.07 ± 0.01 abc	0.07 ± 0.01 ab	0.07 ± 0.01 ab	0.07 ± 0.01 a	0.06 ± 0.01 a	0.07 ± 0.01 a
Harvesting	0.06 ± 0.01	0.06 ± 0.01 abc	0.06 ± 0.01 bcd	0.07 ± 0.01 a	0.07 ± 0.01 a	0.07 ± 0.01 ab	0.07 ± 0.01 a	0.07 ± 0.01 ab	0.06 ± 0.01 ab	0.07 ± 0.01 ab
Cooking	0.06 ± 0.02	0.06 ± 0.01 bc	0.06 ± 0.01 cd	0.06 ± 0.01 c	0.06 ± 0.01 d	0.06 ± 0.01 bc	0.06 ± 0.01 b	0.06 ± 0.01 c	0.05 ± 0.01 bc	0.06 ± 0.01 bc
Dog brushing	0.05 ± 0.01	0.05 ± 0.01 c	0.06 ± 0.01 bcd	0.06 ± 0.01 bc	0.06 ± 0.01 bcd	0.06 ± 0.01 c	0.06 ± 0.01 ab	0.06 ± 0.01 bc	0.05 ± 0.01 c	0.05 ± 0.01 c
Painting	0.05 ± 0.01	0.05 ± 0.01 c	0.06 ± 0.01 d	0.06 ± 0.01 bc	0.06 ± 0.01 cd	0.06 ± 0.01 bc	0.06 ± 0.01 b	0.06 ± 0.01 c	0.05 ± 0.01 abc	0.06 ± 0.01 c
Cleaning (weeding and sweeping)	0.06 ± 0.01	0.06 ± 0.01 ab	0.07 ± 0.01 abc	0.07 ± 0.01 abc	0.07 ± 0.01 abcd	0.06 ± 0.01 abc	0.06 ± 0.01 ab	0.06 ± 0.01 abc	0.06 ± 0.01 ab	0.06 ± 0.01 abc
Significant	0.172[NS]	0.009**	0.001**	0.028*	0.004**	0.012*	0.019*	0.011*	0.009**	0.008**

[i] RFA power spectra were calculated by [alpha (11 to 13 Hz) power]/[total frequency (4 to 50 Hz) power].

NS = nonsignificant; *, ** significant at $P < 0.05$ and $P < 0.01$ by one-way analysis of variance, respectively.

Post hoc analysis a > b > c according to Duncan's multiple range tests, Bonferroni.

Fp1 = left prefrontal lobe; Fp2 = right prefrontal lobe; F3 = left frontal lobe; F4 = right frontal lobe; C3 = left central lobe; C4 = right central lobe; P3 = left parietal lobe; P4 = right parietal lobe; T3 = left temporal lobe; T4 = right temporal lobe.

Table 9. Relative low beta (RLB[i]) power spectrum across seven agro-healing activities.

Variable	Fp1	Fp2	F3	F4	C3	C4	P3	P4	T3	T4	O1	O2
	Mean ± standard deviation											
Raking	0.08 ± 0.01 a	0.08 ± 0.01 a	0.09 ± 0.02 a	0.09 ± 0.01 ab	0.07 ± 0.02 ab	0.09 ± 0.01 ab	0.09 ± 0.01 abc	0.09 ± 0.01 abc	0.08 ± 0.01 abc	0.08 ± 0.01 ab	0.08 ± 0.01 ab	0.09 ± 0.01 a
Planting	0.08 ± 0.01 a	0.09 ± 0.01 a	0.09 ± 0.01 a	0.09 ± 0.01 ab	0.07 ± 0.01 abc	0.09 ± 0.01 a	0.09 ± 0.02 abc	0.10 ± 0.02 a	0.08 ± 0.01 a	0.09 ± 0.02 a	0.08 ± 0.01 a	0.09 ± 0.01 a
Harvesting	0.08 ± 0.02 a	0.08 ± 0.01 ab	0.09 ± 0.01 ab	0.09 ± 0.01 a	0.07 ± 0.01 a	0.09 ± 0.01 abc	0.09 ± 0.01 a	0.09 ± 0.02 ab	0.08 ± 0.01 ab	0.09 ± 0.01 a	0.08 ± 0.01 a	0.09 ± 0.01 a
Cooking	0.07 ± 0.02 ab	0.07 ± 0.01 bc	0.08 ± 0.01 c	0.08 ± 0.01 c	0.06 ± 0.02 bc	0.08 ± 0.02 cd	0.08 ± 0.01 bc	0.08 ± 0.01 d	0.07 ± 0.01 d	0.08 ± 0.01 b	0.07 ± 0.01 bc	0.08 ± 0.01 b
Dog brushing	0.07 ± 0.01 b	0.07 ± 0.01 bc	0.08 ± 0.02 bc	0.08 ± 0.01 bc	0.06 ± 0.02 bc	0.08 ± 0.01 d	0.08 ± 0.00 abc	0.08 ± 0.01 cd	0.07 ± 0.01 cd	0.08 ± 0.01 b	0.08 ± 0.01 abc	0.08 ± 0.01 ab
Painting	0.07 ± 0.02 ab	0.07 ± 0.01 c	0.08 ± 0.02 c	0.08 ± 0.01 bc	0.06 ± 0.02 c	0.08 ± 0.01 bcd	0.08 ± 0.01 c	0.08 ± 0.01 d	0.07 ± 0.01 bcd	0.08 ± 0.01 b	0.07 ± 0.01 c	0.08 ± 0.01 b
Cleaning (weeding and sweeping)	0.08 ± 0.01 a	0.08 ± 0.01 a	0.09 ± 0.02 ab	0.08 ± 0.01 abc	0.07 ± 0.01 bc	0.08 ± 0.01 bcd	0.09 ± 0.02 ab	0.09 ± 0.01 bcd	0.08 ± 0.01 abcd	0.08 ± 0.01 ab	0.08 ± 0.01 ab	0.08 ± 0.01 ab
Significant	0.043*	0.000***	0.000***	0.027*	0.015*	0.003**	0.022*	0.000***	0.004**	0.024*	0.004**	0.006**

[i] RLB power spectra were calculated by [beta (12 to 15 Hz) power]/[total frequency (4 to 50 Hz) power].

*, **, *** significant at $P < 0.05$, $P < 0.01$, and $P < 0.001$ by one-way analysis of variance, respectively.

Post hoc analysis a > b > c according to Duncan's multiple range tests.

Fp1 = left prefrontal lobe; Fp2 = right prefrontal lobe; F3 = left frontal lobe; F4 = right frontal lobe; C3 = left central lobe; C4 = right central lobe; P3 = left parietal lobe; P4 = right parietal lobe; T3 = left temporal lobe; T4 = right temporal lobe; O1 = left occipital lobe; O2 = right occipital lobe.

previous research has reported that participatory horticultural activities elicit greater positive affect and cognitive stimulation than purely decorative or nonparticipatory formats (Zhao et al. 2022), suggesting that the multistep, goal-directed nature of planting and harvesting may help explain their more distributed activation patterns.

Other activities, including cooking, painting, and dog brushing, showed increased activity in the F3 and F4 regions within the RG band, which could indicate enhanced perceptual and attentional engagement with complex sensory cues (e.g., colors, textures, animal movement) in relatively short, focused tasks. By contrast, raking was associated with changes in RA in F3, F4, C4, and P3. Rather than implying a single specific function, this combination may be compatible with a state of relaxed yet task-directed processing during repetitive, rhythmical motor actions guided by spatial feedback. Taken together, these patterns suggest that agro-healing activities with differing motor demands, sensory complexity, and goal structure tend to recruit partially distinct but overlapping cortical networks related to attention, emotional regulation, and executive control, broadly in line with the cognitive–emotional engagement reported in earlier horticultural therapy research (Gonzalez et al. 2010; Murray et al. 2019; Song et al. 2010).

From a practical perspective, these findings offer tentative guidance for the design of agro-healing programs, particularly in highlighting activities that involve focused attention and sensory–motor coordination, such as planting, weeding, and harvesting. Practitioners might, for example, structure sessions to alternate between more attention-demanding activities and relatively calming or repetitive tasks, in line with recommendations to balance stimulation and restoration in nature-based interventions (Bragg and Atkins 2016; Lu et al. 2023). At the same time, the present results should not be taken to imply that EEG differences directly index the "healing potency" of specific activities. Because the tasks differed in physical intensity, cognitive demand, and sensory complexity, at least part of the observed EEG variation is likely to reflect these task characteristics rather than therapeutic effects per se.

Within this context, integrating EEG-informed insights into program development may help generate hypotheses about how to tailor activity sequences or intensities to participant needs, but such applications remain preliminary. Although the current study did not include clinical populations, the observed activation in cortical regions commonly implicated in attention and emotion regulation suggests that agro-healing activities engage neural systems that are relevant to mental health. However, these associations are correlational, and no causal claims can be made. The small sample size (N = 18), the use of a single care farm in Cheongju, South Korea, and the lack of control over outdoor environmental factors (e.g., temperature, light, ambient noise) all limit the generalizability of the findings and may have influenced the EEG signals. Nevertheless, implementing mobile EEG in a naturalistic care farm setting provides a useful starting point for future studies that combine tighter experimental control with ecologically valid tasks, thereby strengthening the scientific rigor and reproducibility of EEG-based agro-healing research.

Future directions. Building on these preliminary findings, future research should recruit larger and more diverse samples, ideally using probability-based strategies, to enhance generalizability across ages, regions, and clinical profiles. It should also employ longer-term and randomized controlled designs to test causality and to examine dose-response effects of specific agro-healing tasks. Integrating multimodal psychophysiology—such as concurrent EEG, heart rate variability, and salivary cortisol—alongside behavioral and self-report outcomes may help triangulate mechanisms. In parallel, studies ought to characterize environmental context with higher spatial–temporal resolution (e.g., microclimate, noise, light, allergens) to model how setting-level factors shape neural responses during real-world activities. Methodologically, mobile or untethered EEG should be paired with task standardization and activity tracking (e.g., inertial sensors, workload indices) to separate movement-related from task-related neural signals. Longitudinal cohorts can then determine whether repeated participation yields sustained gains in attention, emotion regulation, and executive functioning, and whether effects persist after program completion.

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