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CORRESPONDENCE

Better mind, better work: effects of plants on adolescent mental stress as measured by EEG

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Introduction

Educational stressors are a natural part of school life and they affect a scholar's academic achievement and mental health. In Chinese culture, educational stress is surprisingly serious because Chinese youth are expected to pursue educational success to achieve family pride, social mobility, and respect [1], resulting in extremely high educational demands and extra pressure on middle and high school adults [2]. Few studies have examined educational stress among Chinese students [2–7]. Increasing attention has been paid to the benefits of plant activities, including horticultural or gardening activities, which are considered to be supportive for health [8]. However, to date, no studies have been conducted using electroencephalography (EEG) to assess the consistency of the positive effects of gardening on health among young adults. Therefore, the goal of this research was to determine the physiological and psychological relaxing effects of gardening activities on university students.

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Methods

Participants

We hired forty healthy Chinese adult males and females (mean age 19.3 ± 1.3 SD) from Sichuan Agricultural University. The use of alcoholic beverages and other brain affecting drugs was strictly prohibited throughout the experiment. Written informed consent was obtained from each subject after a full explanation of the research methods. This work was approved by the local ethics committee at the College of Landscape Architecture, Sichuan Agricultural University, China.

Materials and methods

Horticultural activity consisted of transplanting common indoor plant using real soil for 10 min while completing a written task using a computer; these activities represented a 10-min common horticultural physical task and a control task, respectively, as shown in Fig. 1. The experiment was performed at a large table, the sides of which were covered with black paper. The temperature, room humidity and luminance were consistently maintained at 21 °C, 56 and 500 lux, respectively. Students were randomly divided into two groups: A and B. The members of group A ($N = 20$) performed the control task, and those in group B ($N = 20$) performed the horticultural task. Both activities were performed individually in a standing position for 10 min.

Measurements and data recording

A NeuroSky MindWave EEG headset was attached to the participants' head in the waiting room before moving to the experimental room. After a 5-min rest in a seated position, the participants performed the given tasks, that is, transplanting the plants or performing a computer task, for 10 min.

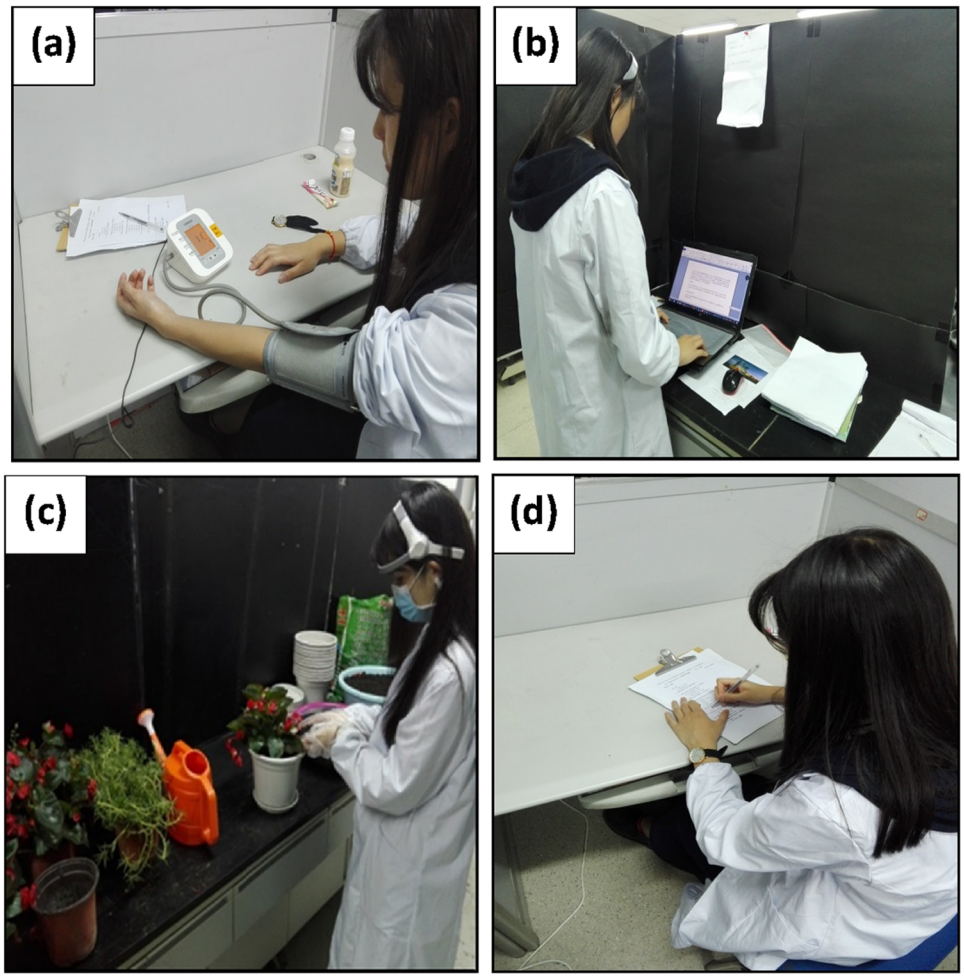

Fig. 1 Photographs of participants during the experiment: **a** initial blood pressure measurements; **b** a subject performing the control activity; **c** a subject performing the horticultural activity; and **d** post-test questionnaires

Table.1 Mean and standard deviation of participants when performing activities

Measurements	Control task (mean ± SD)	Transplantation task (mean ± SD)	*P* value
Systolic blood pressure (mmHg)	115.6 ± 12.0	107.8 ± 6.4	0.024
Diastolic blood pressure (mmHg)	70.7 ± 7.7	69.0 ± 5.9	0.423
Pulse rate	75.9 ± 10.0	75.8 ± 6.7	0.971
EEG-high alpha (power units)	23026.0 ± 2039.0	29,081.4 ± 3158.5	<0.001
EEG-high beta (power units)	17,433.3 ± 1965.5	21,300.2 ± 2293.2	<0.001
STAI	44.0 ± 2.76	37.5 ± 4.57	<0.001
Meditation score	37.49 ± 8.34	49.94 ± 7.05	<0.001
Attention score	38.09 ± 7.96	49.59 ± 7.37	<0.001

Blood pressure and EEG were measured to determine the participants' physiological responses. EEG data, along with attention and mediation scores, were collected and analyzed at 1-min intervals for each experimental site, and the 10-min average values were compared between the two conditions. Each participant completed the State-Trait Anxiety Inventory (STAI) [9] questionnaire before and after each task.

Statistical analysis

A paired *t* test was used to compare the physiological data variables with statistical significance set at $P < 0.05$, and the psychological data variables were compared using the Wilcoxon signed-rank test, with statistical significance set at $P < 0.01$.

Results

Systolic blood pressure (mmHg) was significantly lower after the transplanting task than after the control task. However, no significant difference was observed in diastolic blood pressure (mmHg) or pulse rate. Similarly, subjective evaluations, using the State-Trait Anxiety Inventory (STAI), revealed that the participants' anxiety levels decreased after the transplanting task compared with the control task (Table 1). Moreover, no significant difference in the STAI was observed between the two groups before the tasks were performed. Furthermore, the 1-min analysis revealed that the mean values of the high-alpha and high-beta brainwaves increased during the transplanting task compared with the control task. A significantly higher mean alpha power unit was noted during the total working period after the transplanting task compared with the control task (Table 1). A significantly higher mean high beta power unit was noted during the total working period after the transplanting task compared with the control task (Table 1). The meditation and attention mean scores of the participants were largely increased after the transplanting task compared with the control task (Table 1).

Discussion

In this experiment, we investigated the stress-reducing effects of interacting with plants by measuring psychophysiological responses. The systolic blood pressure analysis results indicated that plants have a positive physiological effect on mental stress, which increases when a person interacts with a stressor. The results of the EEG analysis indicated that plants exert strong physiological relaxing effects on the brain by increasing high-alpha and high-beta wave activities, which decreases when a person is exposed to a stressor. In this experiment, the increase in alpha brainwaves clearly indicated that the participants were calm and mentally relaxed; however, lower-alpha brainwaves revealed stressful conditions. A previous study showed that increases in beta waves are correlated with a highly alert state of mind, whereas beta waves are decreased when drowsy [10]. The STAI scores also indicated that continuously working on mental tasks may have negative effects on one's psychological state, indicating that the participants felt stressed when performing the control task compared to performing the transplanting task.

Conclusions

Our results support the finding that live interactions with plants can reduce systolic blood pressure and enhance alpha and beta brain activities compared with mental work.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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