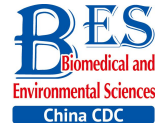


Letter to the Editor



Psychophysiological Effects of Bamboo Plants on Adults*

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The present study was conducted to clarify the psychophysiological relaxation effects of viewing bamboo on university students. Forty healthy Chinese participants enrolled in this study to clarify the psychophysiological relaxation effects of viewing bamboo. The effects of visual stimulation using a pot both with and without a bamboo were recorded by measuring the student's blood pressure, EEG and STAI. We observed that viewing bamboo plants resulted in significantly lower systolic (female, $P < 0.001$; male, $P < 0.001$; $P < 0.05$) and diastolic (female, $P < 0.001$; male, $P < 0.001$; $P < 0.05$) blood pressures, but no changes in the pulse rate (female, $P = 0.09$; male, $P = 0.07$; $P > 0.05$) were observed. The results of the EEG analysis indicated brainwave variation (all $P < 0.05$) and lower anxiety scores ($P < 0.01$) after 3 min of viewing bamboo compared with the control. These findings indicate that visual stimulation with bamboo plants induced psychophysiological relaxation effects on adults.

Currently, social media and mobile phone devices are popular among teenagers and adults. In 1980, scientists observed that 8- to 18-year-olds spend a considerable amount of time playing mobile video games, which resulted in a lack of interest in nature; therefore, these individuals are rarely exposed to natural environments^[1]. The past decade has witnessed an increasing number of behavioral and mental health problems worldwide^[2]. According to the World Health Organization mental health problems currently constitute 10% of the global burden of disease^[3]. These mental health issues are rapidly increasing each year and are becoming significant in all parts of the world. By 2020, mental illness may account for up to 45% of the total diseases worldwide^[4]. In such a situation, increasing attention has been focused on the role of natural environments, such as indoor plants. The effects of

natural elements are increasingly being acknowledged in stressful locations, such as nursing homes and hospitals^[5]. In these environments and many other places, such as offices, human contact with nature is an effective and simple strategy for improving vitality and relieving stress^[5]. People with access to nearby natural settings have been found to be healthier overall than people without such access. Many studies have evaluated the psychological effects of exposure to flowers; however, the physiological relaxing effects of viewing bamboo plants have not been scientifically studied. Bamboo is a well-known and the most preferred plant in Chinese landscape design due to its unique beautiful foliage and fast-growing characteristics. In addition, bamboo is used for indoor and outdoor decoration and for recreation purposes in many public and private parks, schools and nursing homes. The demand for ornamental bamboo plants has increased in the field of interior decoration. Therefore, to clarify the physiological and psychological effects of viewing bamboo plants on human comfort, we recruited Chinese male and female university students.

The experiment was conducted in a conference room of the College of Landscape Architecture in March of 2016. The temperature, relative humidity, and intensity of illumination were maintained at 21 °C, 50%, and 500 lux, respectively. Forty healthy Chinese students (50% male; 50% female) with average (mean \pm SD) ages of 19.6 ± 1.4 years; weights 52.0 ± 6.2 kg; and heights 161.2 ± 3.1 cm from Sichuan Agricultural University, China, were selected for this trial. All students were non-smokers and had no previous record of mental disorders. Before the start of the experiments, the participants were fully informed of the objective and methods of the tests, and their consent to undergo these trials

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was obtained. This study was conducted with the approval of the local Ethics Committee of the College of Landscape Architecture, Sichuan Agriculture University, China. For visual stimulation, we used a fresh bamboo plant in a container, and the control consisted of a pot without bamboo plant (Figure 1).

We presented the experimental method to the participants in the conference room, and each subject was sent to the experimental location and rested in a seated position for 5 min. After their blood pressure was measured, the participants were asked to close their eyes for 10 s, sit quietly and look at the bamboo plant for 3 min. During this time period, EEGs were constantly recorded using the EEG Headset (NeuroSky Mind Wave Beijing Oriental Creation Technology Co., Ltd., China). This device records brainwaves from the forehead (the Fp1 position above the eye). The brainwaves (high alpha; high beta) and meditation score, which were collected at 1-min intervals at each experimental location, were compared based on the 3 min average. The participants' blood pressure was measured using an Omron HEM-7201 upper arm intelligent electronic sphygmomanometer. Finally, the subjects completed the State-Trait Anxiety Inventory (STAI) questionnaire^[6] which was used to determine the participants' level of anxiety.

Statistical analyses were performed using SPSS 16.0 (IBM Armonk, New York, USA). A paired *t*-test was used to compare the mean values between physiological data, with significance at $P < 0.05$, and the Wilcoxon signed-rank test was used to analyze

psychological data, with significance at $P < 0.01$.

According to the paired *t*-test, the blood pressure in males and females significantly decreased after 3-min of viewing the bamboo plant compared with the control (systolic blood pressure of the females, bamboo view: 101.0 ± 3.7 mmHg; control view: 105.9 ± 5.2 mmHg; $P < 0.001$. diastolic blood pressure, bamboo view: 60.9 ± 5.5 mmHg; control view: 67.5 ± 5.8 mmHg; $P < 0.001$; $P < 0.05$. systolic blood pressure of the males, bamboo view: 108.1 ± 6.2 mmHg; control view: 113.0 ± 5.8 mmHg; $P < 0.001$. diastolic blood pressure, bamboo view: 60.9 ± 6.0 mmHg; control view: 68.9 ± 7.7 mmHg; $P < 0.001$; $P < 0.05$). No significant differences in the pulse rate were observed (female: $P = 0.09$; male: $P = 0.07$; $P > 0.05$). Alpha and beta brainwaves, which reflect brain activity, increased every minute during visual stimulation with the bamboo plant compared with the control. Compared to the mean values during the control viewing period, most of the high alpha means values in males and females were higher when viewing the bamboo (Figure 2A) during the 1-min analysis. According to the paired *t*-test, these differences were significant ($P < 0.05$) (males, bamboo view: 29360.2 ± 1077.7 ; control view: 21552.0 ± 1288.5 ; $P = 0.02$; females, bamboo view: 30149.3 ± 642.9 ; control view: 22428.8 ± 2537.1 ; $P = 0.04$; Figure 2B). Similarly, during the 1-min analysis, most of the high beta means value in males and females viewing the bamboo plant were higher than the control values (Figure 3A). Furthermore, according to the paired *t*-test, these differences were

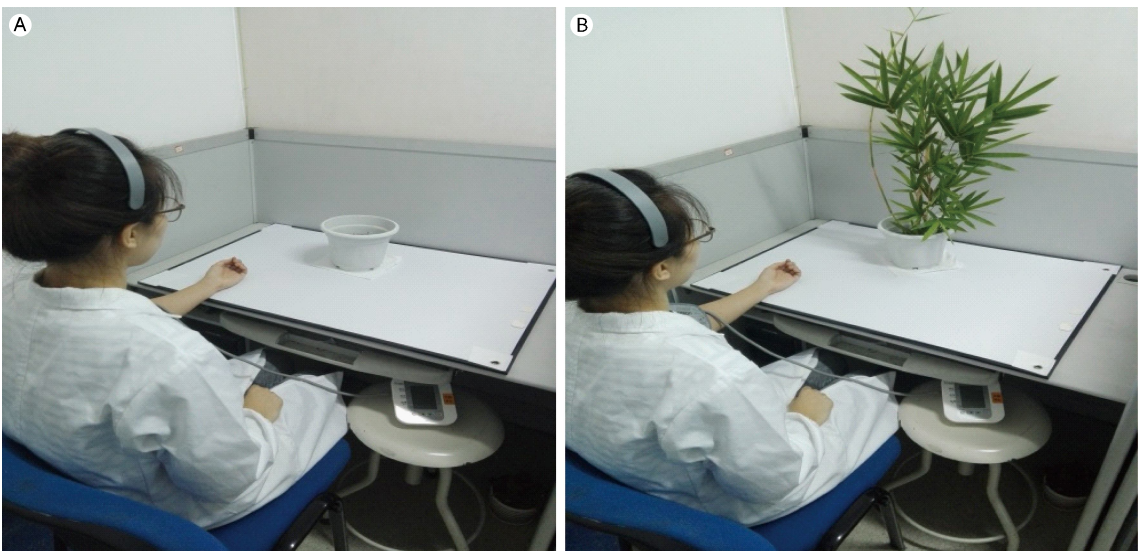


Figure 1. Photographs of experiments. (A) A subject viewing an empty pot (control); (B) A subject viewing bamboo.

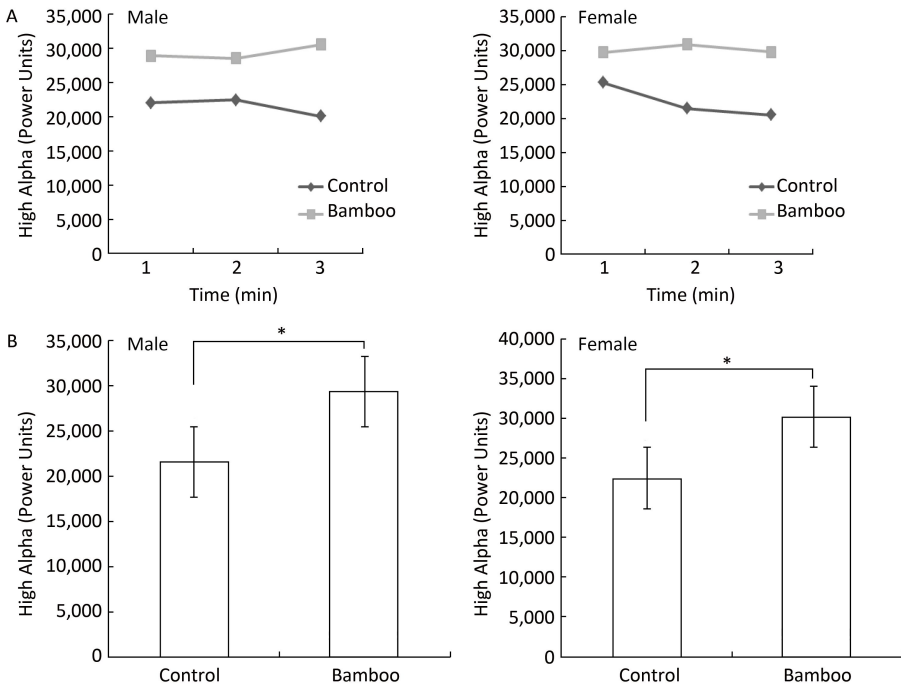


Figure 2. One-min averages and the overall mean high alpha (power units) values of EEG variability between males and females viewing bamboo and the control. (A) Change in each 1-min high alpha (power units) value; (B) overall mean high alpha (power units) values; $N = 40$; mean \pm SD; * $P < 0.05$ vs. bamboo view group; paired t -test.

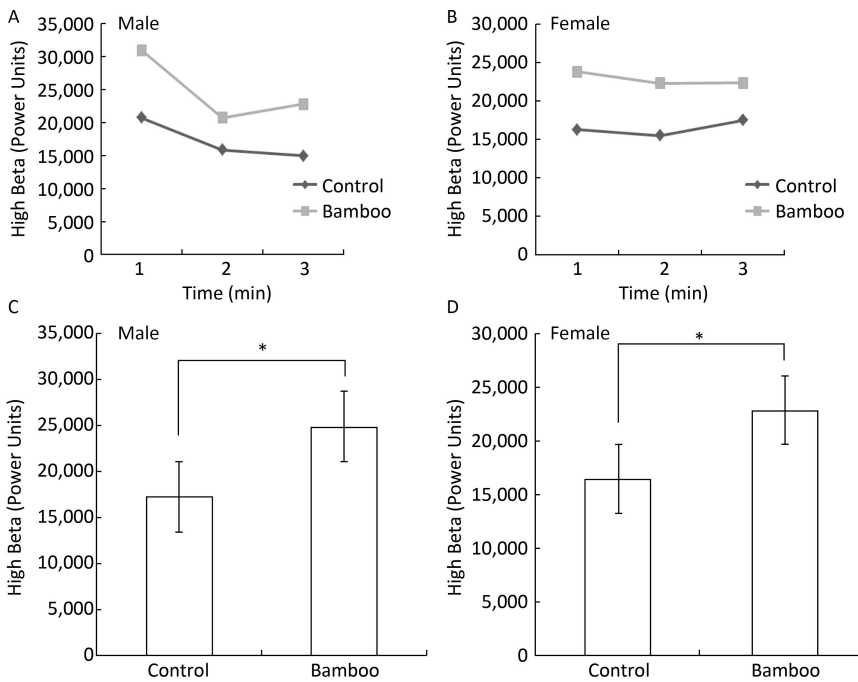


Figure 3. One-min averages and the overall mean high beta (power units) values of EEG variability between males and females viewing bamboo and the control. (A) Change in each 1-min high beta (power units) value; (B) overall mean high beta (power units) values; $N = 40$; mean \pm SD; * $P < 0.05$ vs. bamboo view group; paired t -test.

significant ($P < 0.05$) (males, bamboo view: 24849.8 ± 5396.9 ; control view: 17189.6 ± 3093.0 ; $P = 0.03$; females, bamboo view: 22825.4 ± 859.6 ; control view: 16435.7 ± 1000.6 ; $P = 0.01$; Figure 3B). The Mind Wave EEG Headset output meditation (relaxation) scores and the paired t-test results indicated that females showed higher relaxation than males after viewing the bamboo plant compared with the control (female meditation score, bamboo view: 71.3 ± 8.3 ; control view: 47.4 ± 12.8 . male meditation score, bamboo view: 67.0 ± 22.1 ; control view: 55.2 ± 17.1 ; $P < 0.05$).

According to the Wilcoxon signed-rank test STAI questionnaire, the participants' mean anxiety score significantly decreased after viewing the bamboo plant compared with the controls (STAI score females, bamboo view: 32.7 ± 6.7 ; control view: 37.9 ± 7.4 . STAI score males, bamboo view: 34.0 ± 6.7 ; control view: 39.2 ± 7.1 ; $P < 0.01$).

We investigated the relaxing effects of viewing a bamboo plant by comparing the physiological and psychological changes in participants viewing bamboo or a pot without a bamboo plant. The physiological evaluation indicated that significant differences in blood pressure occurred after viewing a bamboo plant. Compared with the control view, the participants' systolic and diastolic blood pressure decreased, although no significant changes in pulse rate were observed. These results are similar to the findings of a previous study in which patients who were exposed to forest scenes exhibited decreased blood pressure^[7].

Moreover, compared with views without plants, views that incorporate nature or indoor plants have been shown to have relaxing effects on workers by lowering their blood pressure^[8]. Furthermore, Park and Mattson have also noted the positive impact of plants on patients in hospital rooms and observed that the participants' blood pressure decreased in the presence of plants^[9]. The observed changes in blood pressure indicated that plants had a significant impact on the participants' autonomic nervous system. The autonomic nervous system, which contains the sympathetic and parasympathetic nervous system, is directly involved in an increase or decrease in blood pressure. Normally, the sympathetic nervous system is directly associated with an increase in blood pressure, whereas the parasympathetic nervous system is associated with a decrease in blood pressure^[10]. In this study, the lower blood pressure indicated that the participants became more relaxed and happier while looking at a

bamboo plant. Why do plants reduce stress? To answer this question, we record EEGs of the participants. Our results indicate that both conditions affected the EEGs; for example, during visual stimulation with the bamboo plant, increased high alpha-wave and high beta-wave activity were observed, which means improved relaxation, and attention. In other words, viewing the bamboo produced more positive attitudes, and more brain functions compared with the control. In addition, when the subjects looked at the bamboo plant, their relative fast alpha power spectrum increased indicating improved relaxation and creativity compared with that observed for the control. In contrast, our results showing an increase in the beta waves indicated that the participants were more attentive thus lower values indicated a lack of concentration. In general, increases in beta wave activity occur during an alert situation, and lower beta waves are observed during a state of drowsiness. Brain waves naturally occur during both resting and active conditions. Our emotions, thoughts, and behaviors are the reflection of neuronal activity inside the brain. EEGs record these electrical activities and represent them as waves. Brain waves with slower frequencies are dominant when we feel slow, dreamy or tired. Furthermore, higher frequencies are dominant when we feel excited or super-alert. The NeuroSky Mind Wave Sense meter meditation results showed that the subjects' meditation mean scores were higher when viewing the bamboo plant, which means that the subjects were calmer than they were in the control. In contrast, a lower meditation score indicates anxiety, stress or perhaps lack of interest. One study indicated that the presence of foliage plants affects meditation and attention, which are useful for boosting an individual's work performance. However, what are these brain waves and where do they originate? The last 15 years have witnessed the ascent of an alternative view, that of embodied or enactive cognition. This new wave arose because the previous doctrine failed to account even for the most elementary coping with the world: walking, perceiving objects in a natural setting, and imagination. Slowly, the basis of the mind began to be considered the body in coupled action, that is, the sensory-motor circuits establish the organism as viable in situated contexts. From this perspective, the brain appears as a dynamic process (and not a syntactic one) of real-time variables with a rich self-organizing capacity (and not representational

machinery). Therefore, in this sense, the mind is not in the head since it roots in the body as a whole and in the extended environment where the organism finds itself. We believe that this research provides important results on the relationship between humans and nature, and it also provides valuable information on the differences in brainwave activity that occur in different environments. We highly recommend that urban planners should pay more attention to indoor plants to improve the mental health of humans. However, this study has a few limitations. For example, we used only one type of bamboo plant; thus, in the future, studies with different flowering plants should be performed to verify their relaxation effect. Second, the effects of bamboo plants on older people should be evaluated to determine whether there are differences in the brainwaves between elderly and young individuals.

Our results show that viewing bamboo plants enhances physiological and psychological relaxation.

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