

Healing Effects of Foliage Plants Using Physiological and Psychological Characteristics

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Foliage plants serve as interior accessories and are placed in indoor spaces, such as offices, hotels, restaurants, and homes. Recently, their healing effects have attracted much attention. In this investigation, the healing effects of foliage plants on human subjects performing a computer task were examined by measuring salivary amylase activity, blood pressure, and pulse as physiological indices, and by using the profile of mood states (POMS, the Japanese edition) as a psychological index. The salivary amylase activities of the subjects working in a room with foliage plants were significantly decreased compared with those of the subjects working in a room without plants. When comparing average increase/decrease rates between cases immediately after and 30 min after task-loading, the rates of the salivary amylase activity, anger-hostility, vigor of the subjects in the cases with and without plants are -11.1 and 3.5% , -3.4 and 0.3% , and 3.2 and -0.6% , respectively. It is evident that foliage plants have healing effects on workers.

1. Introduction

Recently, the healing effect of plants has gained public attention and some reports on such an effect have been made.⁽¹⁻³⁾ Forest and horticulture therapy has been studied in detail. A dozen studies of plants' healing effect have been carried out outdoors. Japanese spend 90% of their weekday and 88% of their holidays indoors according to research.⁽⁴⁾ Thus, it is very important to achieve a healing effect in an indoor environment. Foliage plants have a healing effect on humans and are found in many indoor spaces, such as hotels, offices, commercial buildings, hospitals, restaurants and houses. Humans have lived with plants since the dawn of time. It has been reported that plants have various effects on the physiology and psychology of humans. However, most previous investigations have been carried out under conditions markedly different from those of an ordinary indoor environment because the evaluations were conducted using an

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electroencephalograph.⁽⁵⁾ A study of the stress-buffering effect using salivary cortisol has also been carried out. However, in these studies, the effect of plants on the same human subject was not examined under two conditions, namely, with plants and without plants.⁽⁶⁾

There is currently no clear definition of “healing” and the evaluation method for healing differs depending on the research field and subject.⁽⁷⁾ Thus, in this study, the healing effect is treated as a stress-buffering effect. The analysis of stress markers using salivary amylase activity is noninvasive and is not determined by the subject undergoing measurement of stress. Such markers are excellent owing to their ease of determination and round-the-clock availability for examination. The secretion of hormonelike cortisol has a time delay of 20–30 min after stimulation. The secretion of salivary amylase is stimulated by the parasympathetic action and the response time is about 1 min.⁽⁸⁾

The healing effect of foliage plants on data entry work is verified using physiological and psychological response characteristics in this study. Salivary amylase was adopted as a physiological index because its response time was short. Blood pressure and pulse were also measured. The profile of mood states (POMS) was used as the psychological index. The POMS test is a shorter version.

2. Experimental

2.1 Experimental room and plants used

The layout of the experimental room is shown in Fig. 1. There are windows on the left and at the back of the room. The window blinds were pulled down. The human

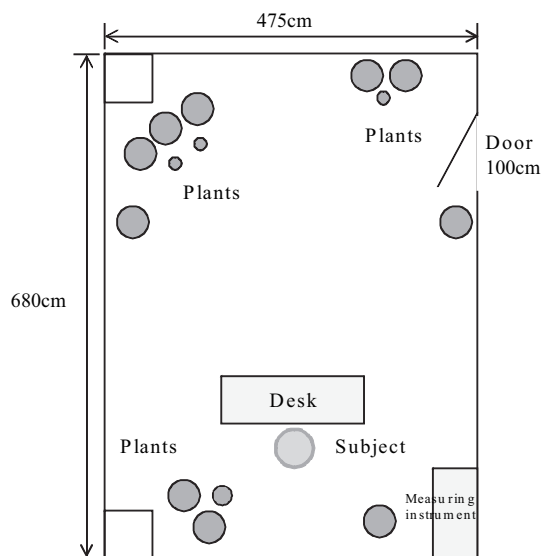


Fig. 1. Layout of experimental room.

subject was not influenced by the weather. White fluorescent lamps lighted up the room and the illumination intensity just on the workbench was 730 lx on average. The room was heated up using electric heaters and the room temperature was 18 to 20°C. The average humidity was 35% RH.

The plants placed are as follows: schefflera (three large pots and one small pot), *Phoenix roebelenii* (two large pots), *Dracaena marginata* (two large pots), hurricane palm (one large pot), indian rubber fig (one large pot), pothos (one medium-sized pot), and guiana chestnut (cv: *Pachira aquatica*, two large pots and three small pots). These plants were chosen because they were popular indoor plants. The height of the plants growing in large pots was about 160 to 230 cm from the pot bottom. The height of the plants in the medium-sized pot was about 50 cm and that of the plants in the small pots was about 30 cm. The arrangement of the plant pots was decided in consideration of design, for example, golden proportion. The photograph of the experimental room with the plants is shown in Fig. 2. A room without plants was also used as control, and the layout was exactly the same.

2.2 Measurement item

A salivary amylase monitor (NIPRO CM-21) and a digital sphygmomanometer with a pulse monitor (OMRON HEM-7011) are adopted as physiological indices. These measurement values increase when a person is subjected to increasing stress level.^(8,9) The POMS (shortened version) test was used as the psychological index. POMS is a mood-evaluation method that uses a questionnaire. It can evaluate the mood and emotion of subjects, which change according to their condition. It can evaluate the six mood-scale factors all together, namely, tension-anxiety, depression-dejection, anger-hostility, vigor, fatigue and confusion. It was shown to have effective applications in workplaces, schools and clinical sites.⁽¹⁰⁾ There are thirty items in the POMS test used in this study.



(a)



(b)

Fig. 2. Experimental room with plants. (a) Front view of the experimental room. (b) Back view of the experimental room.

2.3 Human subject and experimental procedure

The group of subjects was composed of twenty-two people, namely, twenty university students (20's) and two professors (40's) (male 13 and female 9). The experimental process is shown in Fig. 3(a). The subjects were divided into two groups (A and B groups). Each group consisted of eleven members. First, a member of the A-group worked in an experimental room with plants (A-room) one by one. Then, a member of the B-group worked in another room without plants (B-room). When the A-group members finished the work, they were transferred to the B-room. When the B-group members finished their work, they were transferred to the A-room to work in the same way. Namely, the crossover method was adopted in the study. The experimental overview was represented and the physiological indices (i.e., salivary amylase, blood pressure and pulse) were measured before the subjects started their work. Then, a demonstration of the experiment was carried out and the subjects practiced POMS. They were given a relaxation time to reduce tension for 5 min. After that, each subject entered the room to begin the work. The time chart of the experiment is shown in Fig. 3(b). The salivary amylase activity, blood pressure and pulse were measured. The POMS was also completed by the subject in the same period (1). Computer entry work was given to the member as a work load for 15 min, and the measurement was carried out shortly after the work (2). After that, the subject was allowed to rest in the room for 30 min and the third measurement was carried out (3). The subject was also given thirty-minute break in the lobby and before switching rooms to carry out another round of work, namely, from the A-room to the B-room or vice versa. Finally, a simple questionnaire was given to the subjects, which simply asked whether the subject likes or dislikes foliage plants.

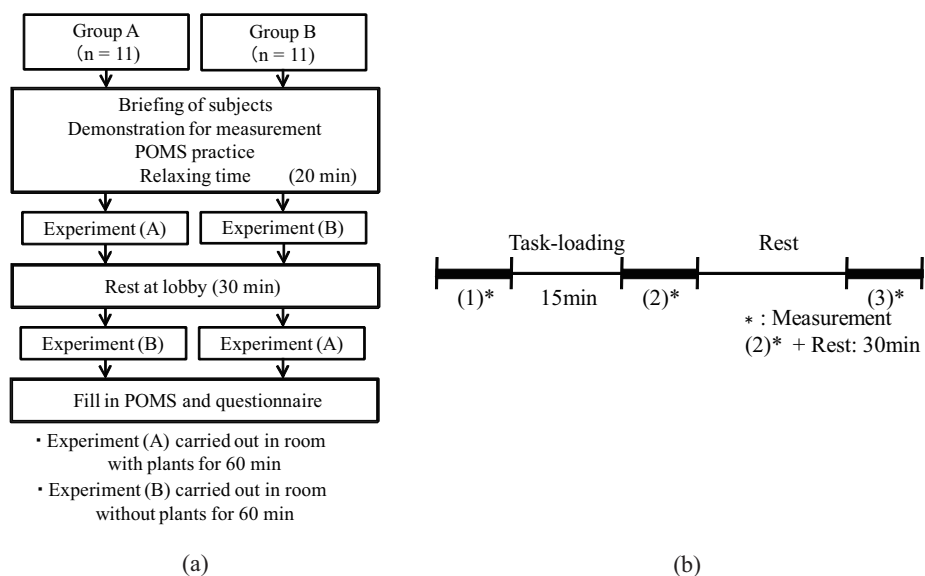


Fig. 3. Experimental process and time chart. (a) Experimental process. (b) Time chart of experiment.

3. Experimental Results

3.1 Physiological and psychological responses

The averages of all the subjects for each measured item are summarized in Table 1. The result of POMS was converted to T-score (normal distribution of Z-score) for considering age gap.⁽¹⁰⁾ There is a small difference in the averages of the measurement items except amylase activity. The t-test was carried out for all related data. Results show that there are significant differences in amylase activity and tension-anxiety between cases immediately after and 30 min after task-loading. The result of amylase activity is shown in Fig. 4. In the figure, the index shows a significant difference in the case of the presence of plants and the healing effect is recognized. The data for tension-

Table 1
Physiological and psychological responses in the presence/absence of foliage plants.

		With plants			Without plants		
		Before task-loading	Immediately after task-loading	30 min after task-loading	Before task-loading	Immediately after task-loading	30 min after task-loading
Amylase activity (kU/L)	AA	32	40	31	29	34	31
Blood pressure (mmHg)	BP	121	117	117	118	116	115
Pulse (beats/min)	P	67	67	67	66	67	66
POMS							
Tension-Anxiety	T-A	45	44	40	42	44	41
Depression-Dejection	D-D	46	45	44	44	44	44
Anger-Hostility	A-H	43	42	40	41	41	41
Vigor	V	36	35	36	35	33	33
Fatigue	F	43	46	43	42	45	44
Confusion	C	51	50	48	49	51	49

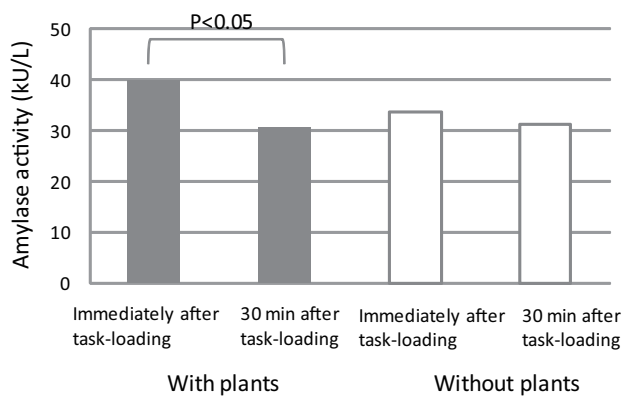


Fig. 4. Changes in salivary amylase activity due to task-loading.

anxiety is shown in Fig. 5. In the figure, the index drops to a lower value after 30 min regardless of the presence or absence of plants. The subjects were requested to enter data correctly and quickly. It is thought that their tension-anxiety was relieved by finishing the data entry process even in the absence of plants.

3.2 Evaluation due to increase-decrease rate

As there were many individual variations in the measurement data, the increase-decrease rate was evaluated. The rate is derived using $((2)-(1))/(1)$, where (1) and (2) indicate the indices before and immediately after task-loading, which are shown in Fig. 3(b). Each average rate is represented in Fig. 6. Abbreviated index names in the figure are shown in Table 1. AA and F increased by 20 and 7%, respectively. T-A was unchanged regardless of the presence of plants. It shows only a 6% increase in the absence of plants. C shows a decrease of 2.4% in the presence of plants and an increase

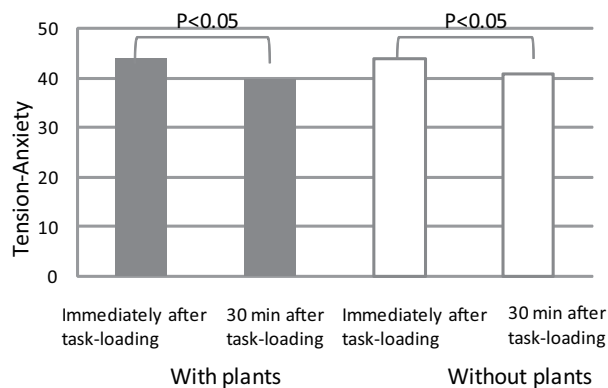


Fig. 5. Changes in tension-anxiety due to task-loading.

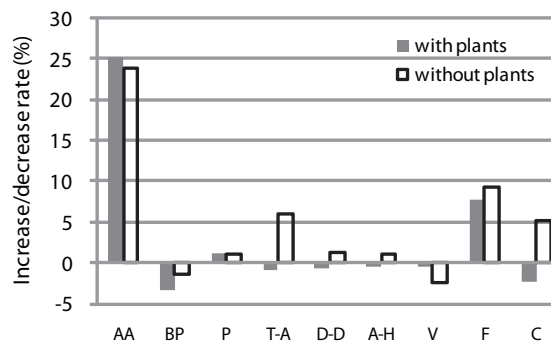


Fig. 6. Increase/decrease rates obtained before and immediately after task-loading.

of 5.2% in the absence of plants. Even though there is some difference in T-A, the presence of plants does not generally markedly affect physiological and psychological conditions. It is thought that this result is caused by the fact that subject could not have breathing room in the task-loading for 15 min.

Another increase-decrease rate was introduced. The rate is derived using $((3)-(2))/(2)$, where (2) and (3) indicate the indices immediately after and 30 min after task-loading, which are shown in Fig. 3(b). Each average rate is represented in Fig. 7. AA shows a decrease of 11.1% in the presence of plants and an increase of 3.5% in the absence of plants. A-H decreases by 3.4% in the presence of plants and increases by 0.3% in the absence of plants. These values indicate a negative mood. V is a positive mood. It increased by 3.2% in the presence of plants and decreased by 0.6% in the absence of plants. Although T-A and F decrease in the absence of plants, the rate is larger in the presence of plants. As for the result, plants have a relaxing effect, which is derived from physiological and psychological indices.

3.3 Individual differences influencing plant installation

The stress reduction by placing plants varies considerably, depending on the individual. The histograms in the case immediately after and 30 min after task-loading were prepared with respect to each item evaluated. The histograms are indicated in Fig. 8. The data obtained in the presence and absence of plants are approximated using a normal distribution. The effect of plant installation becomes larger when the data obtained in the presence of plants are smaller than those obtained in the absence of plants and when the difference between the data is larger. The average fatigue does not differ in Fig. 8(a), but the index varies widely. The average amylase activity is low in the presence of plants and the healing effect of plant installation is recognized. The effect is shown in Fig. 8(b). The histogram cannot exactly fit the normal distribution function. The histograms for tension and anxiety (T-A) fit the normal distribution. The average for the presence of plants is low and the index varies largely. The histogram is indicated in Fig. 8(c). The

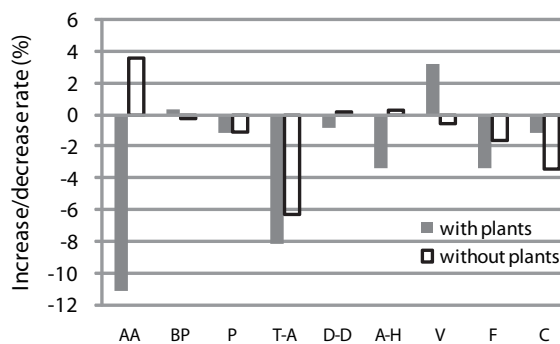


Fig. 7. Increase/decrease rates obtained immediately after and 30 min after task-loading.

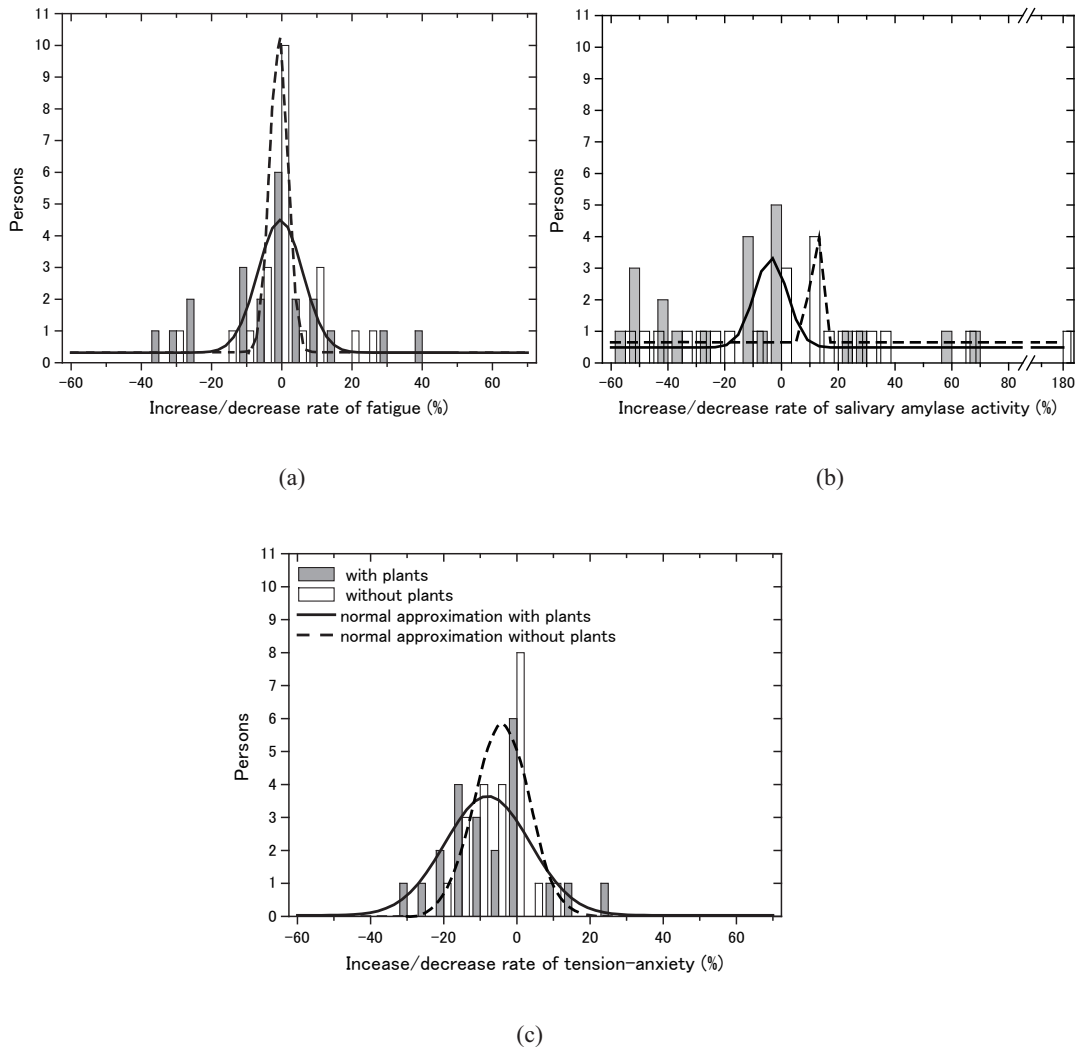


Fig. 8. Histogram of increase/decrease rate in the presence/absence of foliage plants. (a) Fatigue. (b) Amylase activity. (c) Tension-Anxiety.

degrees of coincidence with the approximated functions using the normal distribution for all the items, except amylase activity, are high, and the effect of plants is considered using the standard deviations shown in Fig. 8. The result is indicated in Fig. 9. In the figure, σ_{ip} means standard deviation in the presence of plants and σ_{np} means that in the absence of plants. σ_{ip}/σ_{np} means the degree of the effect of plant installation in terms of individual differences. As for the result, the amylase activity in the presence of plants is

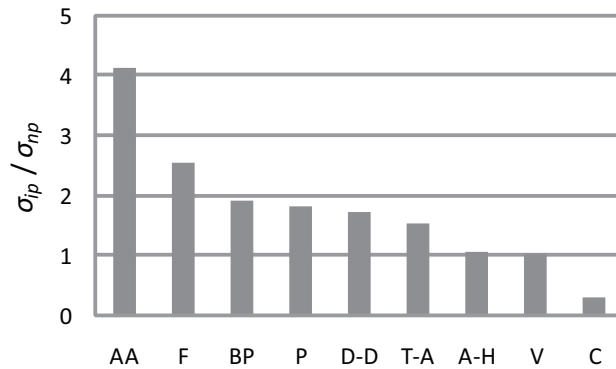


Fig. 9. Effect of plant installation using standard deviations for measurement items.

individual differences. As for the result, the amylase activity in the presence of plants is the highest. It is fourfold that in the absence of plants. The fatigue, however, is about 2.5-fold. Systolic blood pressure, pulse, depression-dejection and tension-anxiety are about 1.5–2-fold. Anger-hostility and vigor remain almost the same. Only the variance of confusion decreases with plant installation. However, it is necessary to re-examine these carefully. When the plants' healing effect is studied, there are two item groups, namely, the group that clearly shows individual differences and the group that shows no clear difference. Careful attention is necessary to investigate the plants' healing effect.

4. Conclusion

The healing effect of plants in an office environment was examined. A computer entry task was adopted as the load. Salivary amylase activity, systolic blood pressure and pulse were measured as physiological indices. POMS test was carried out to derive the psychological index. Salivary amylase activity decreased significantly owing to the presence of plants. The increase-decrease rates of the indices immediately after and 30 min after task-loading were examined. The amylase activity and anger-hostility when plants were placed decreased and increased in the absence of plants. Vigor increased when plants were placed and decreased when plants were not placed. Consequently, it becomes obvious that plants have a healing effect on humans.

A questionnaire survey of the subjects was carried out after the experiment. The question was whether or not one likes foliage plants. The result shows that there is no relationship between the indices and that they are similar between men and women. The difference in age could not be investigated owing to the insufficient number of subjects. Thus, it is required to examine the indexes using more subjects. We predict a difference in age. Data entry was adopted as a stress in this study. Some subjects felt no stress with the load. A method that adds stress must be considered.

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