Potential of a Small Indoor Plant on the Desk for Reducing Office Workers' Stress

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SUMMARY. **In modern society, stress reduction in the workplace is a pressing issue. Although many studies have been done on the psychological and physiological effects of indoor plants, the majority of them have been conducted in laboratory or quasi-office settings. The objective of this study was to verify the stress reduction effects of the presence of small indoor plants on employees in a real office setting. We investigated the changes in psychological and physiological stress before and after placing a plant on a worker's desk. Sixty-three office workers at an electric company in Japan were the participants of this study. The participants were directed to take a 3-minute rest while sitting at their desk when they felt fatigue. There were two phases of the study: a control period without plants and an intervention period when the participants were able to see and care for a small plant. We measured psychological stress in the participants using the State-Trait Anxiety Inventory (STAI). As an index of physiological stress, the participants measured their own pulse rate throughout the study. STAI scores decreased significantly after the intervention period ($P < 0.05$). The ratio of the participants whose pulse rate lowered significantly after a 3-minute rest increased significantly during the intervention period ($P < 0.05$). Our study indicates that having opportunities to gaze intentionally at nearby plants on a daily basis in the work environment can reduce the psychological and physiological stress of office workers.**

The importance of preventing mental health disorders in workers has been increasing in Japan (Ministry of Health, Labour and Welfare, 2016). The Japanese government passed legislation that revised the Industrial Safety and Health Act such that, beginning in December 2015, business establishments with more than 50 employees are now required to conduct medical examinations (stress checks) of all employees (Ministry of Health, Labour and Welfare, 2014). This stress check system is aimed at preventing mental health issues in the workforce, promoting awareness of stress in the workers themselves, and amelioration of stress in the work environment (Ministry of Health, Labour and Welfare, 2016). The results of a field survey of industrial safety and health by the Ministry of Health, Labour and Welfare in 2016 revealed that 59.5% of employees had work-related issues that might cause high levels of stress, distress, and anxiety (Ministry of Health, Labour and Welfare, 2017a). The fact sheet on workers' compensation for overwork-death and stress-death announced by the Ministry of Health, Labour and Welfare in 2017 reported that the number of workers' compensation claims for mental disorders caused by work-related psychological strain was on the increase (Ministry of Health, Labour and Welfare, 2017b). The adoption of greenery into the office environment is becoming widespread as the need for improving mental health becomes greater. Many studies have been done on the psychological and physiological effects on workers of having indoor plants in the work environment. The outcomes addressed in these studies have been wide-ranging. Dravigne et al. (2008) reported positive effects from the presence of office plants, window views of green spaces, or both on job satisfaction and also on the overall quality of life of office workers. Other studies have focused on more specific aspects of human health: mood (Larsen et al., 1998; Shibata and Suzuki, 2001, 2002, 2004), perceived stress (Bringslimark et al., 2007; Dijkstra et al., 2008; Genjo and Matsumoto, 2016; Lohr et al., 1996), health and discomfort symptoms including fatigue (Fjeld, 2000; Shibata and Suzuki, 2001), productivity (Bringslimark et al., 2007; Larsen et al., 1998; Lohr et al., 1996; Matsumoto and Genjo, 2012), task performance (Shibata and Suzuki, 2001, 2002, 2004), attention capacity (Raanaas et al., 2011), and workplace satisfaction (Nieuwenhuis et al., 2014).

In addition to looking at different human impact outcomes, studies have been conducted that focused on specific independent variables. Researchers examined the size and volume of greenery (Nishina, 2008); the number of plants installed (Imanishi et al., 2002; Larsen et al., 1998); the kinds of plants (Genjo and Matsumoto, 2016; Imanishi et al., 2002); the shape, size, and distance of the plants from the participant (Hasegawa and Shimomura, 2011); and the index of greenness of an interior space (Choi et al., 2016). Most of these studies were conducted in laboratory or quasi-office settings.

A more limited number of studies targeting office workers in real office settings have also been conducted (Bringslimark et al., 2007; Fjeld, 2000; Genjo and Matsumoto, 2016; Imanishi et al., 2002; Matsumoto and Genjo, 2012; Nieuwenhuis et al., 2014; Nishina, 2008; Yadomaru et al., 2016). In these studies, indoor plants were placed on the floor, windowsills,

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Units

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
10.7639	fc	lx	0.0929
0.3048	ft	m	3.2808
0.0929	ft^2	m^2	10.7639
2.54	inch(es)	cm	0.3937
(°F – 32) ÷ 1.8	°F	°C	(°C × 1.8) + 32

shelves, desks, or all of these options in the office to provide visual access to the plants.

Some earlier studies reported that the presence of indoor plants in the workplace was conducive to positive psychological (Fjeld, 2000) and physiological effects (Lohr et al., 1996; Matsumoto and Genjo, 2012). On the other hand, Bringslimark et al. (2007) reported that the greater the number of plants placed within 1 m of a participant's desk, the greater the level of perceived stress. Larsen et al. (1998) also reported that with an increase in the number of plants in the office there was a corresponding decrease in performance on a letter identification productivity task. They compared three plant conditions: without plants, with a moderate number of plants (occupying 7.16% of the total cubic office space), and with a high number of plants (occupying 17.88% of the total cubic office space).

Most of the previously mentioned studies focused on the psychological and physiological effects of passive interaction with the plants. Nishina (2008) studied the effects of active involvement with plants. He reported that allowing the participants to choose and care for the plants in the study enhanced their satisfaction and contributed to the mitigation of stress in the workplace.

The objective of this study was to verify the stress-reducing effect of gazing intentionally at a plant in a real office setting when a worker felt fatigue during office hours. Each plant used in the study was chosen and cared for by the worker. As many previous studies have substantiated, both passive and active involvement with plants in the workplace contributes to mitigation of office worker stress and fatigue. In our study, the participants were provided daily visual access to plants by having plants on their desks (a passive involvement with plants). They also had the opportunity to choose and to care for those plants (an active involvement with plants). Furthermore, we considered that intentionally gazing at the plants was an active, but not physical, involvement with plants that office workers could do quickly and easily at their desks.

Our hypothesis was that a small plant on a desk had the potential to reduce stress 1) by allowing participants to transfer their gaze intentionally to the plant and to have a rest without cognitive engagement, and 2) by providing participants the opportunity to take care of a plant that they themselves chose. We chose to use small plants that did not take up very much workspace. Our study sought to explore the practical use of indoor plants to benefit the mental health of office workers.

Materials and methods

Participants

A privately owned electric company in Japan funded the research from Jan. to Feb. 2017. We recruited participants in this study via interoffice e-mail. No incentives were offered and, of 1500 employees in 44 departmental offices, 75 employees from four departmental offices volunteered. After oral and written explanation of the study objectives and procedures, written informed consent was obtained from every participant. During the course of the study, six participants withdrew, so the total number of participants was 69, consisting of six managerial and 63 nonmanagerial staff. To eliminate the potential impact of the difference in responsibility levels, the data from the managerial participants were removed from the statistical analyses. The finished study was of 63 nonmanagerial employees who performed desk work on PCs [33 males, age 26–58 years, 38.7 ± 9.3 years (mean ± SD); and 30 females, age 24–58 years, 41.6 ± 9.6 years]. All participants worked 8 h per day (0900–1200 and 1300–1800 HR), 5 d per week.

This study procedure was reviewed and approved by the Ethics Committee, Graduate School of Landscape Design and Management, University of Hyogo, Awaji, Japan.

Work environment

Each participant had a PC and a telephone on the desk. The participants worked on several different floors. Each floor was open-plan and 1260 m^2 (35 × 36 m) in area. Before the study, there were no plants in the office. Some of the participants' desks were near the windows and others were not. However, the window blinds were always drawn to block the sunlight. Therefore, the participants whose desks were near a window did not have a window view. The heating, ventilation, air conditioning, and lighting settings inside the buildings were constantly maintained as follows: room temperature, 20 to 24 °C; humidity, 40% to 50%; illuminance, 500 to 700 lx. We determined that all the participants were in very similar settings, and the proximity of desks to the windows was not considered to be a significant factor in this study.

Protocol and measurement tools

Protocol. The experimental period consisted of two phases. The first week (10–16 Jan.) was a control period, without plants, and the next 4 weeks (18 Jan.–14 Feb.) was an intervention period, with the plants placed on the desks. Considering that 2 weeks was necessary for the participants to learn how to care for plants, and an additional 2 weeks was necessary to get used to taking care of the plants, we decided that an intervention period of 4 weeks was required. During the control period, the participants had nothing new to learn. Therefore, we set the control period to 1 week (5 working days).

We collected information on the participants' psychological and physiological stress throughout the study. A psychological stress measurement was conducted at the end of the work day (1800 HR) twice during the experimental period [i.e., at the end of the control period (16 Jan.) and at the end of the intervention period (14 Feb.)]. As an indicator of physiological stress, participants' pulse rates were recorded twice every working day (i.e., once in the morning and once in the afternoon) when the participants felt fatigue. The pulse rate readings were taken during both the control and the intervention periods. Open-ended feedback questionnaires about their experience were also completed by the participants at the end of the experimental period.

Measurement tools. We evaluated the participants' psychological stress using the STAI (Spielberger et al., 1983) Japanese version [STAI-Form JYZ (Hidano et al., 2000)]. Anxiety is thought to be a variety of stress (Aiken, 1961). The STAI can be used to measure two different types of anxiety: state anxiety and trait anxiety. State anxiety indicates a transient psychological state related to an anxiety-arousing event. Trait anxiety indicates a relatively settled tendency toward anxiety. STAI-Form JYZ consists of two self-report scales: a scale for state anxiety (Y-1) and a scale for trait anxiety (Y-2). Both scales consist of 10 anxiety-present items and 10 anxiety-absent items. Y-1 poses the question: How do you feel about the following 20 items *this very moment*? In contrast, Y-2 asks, How do you *usually* feel about the following 20 items? The 20 responses to the question posed are each scored using a 4-point Likert scale.

We speculated that placing a small indoor plant on the worker's desk, gazing at the plant intentionally, and taking care of it for 4 weeks would impact not only the momentary psychological condition, but also the more pervasive everyday psychological condition. So we decided to use the Y-2 only as the measurement tool. Examples of the anxiety-present statements in Y-2 are as follows: "I worry too much over something that really doesn't matter" and "Some disturbing thought runs through my mind and bothers me." The reliability coefficient of the Japanese version of STAI (Y-2) by Nakazato and Mizuguchi (1982) was 0.71 in comparison with 0.77 of the original edition.

We recorded physiological stress by measuring the pulse rates of the participants. During the control period, the participants themselves conducted a 30-s pulse reading when they felt fatigue, and then a second reading after 3 min of intentionally gazing at the desktop. During the intervention period, the participants took the first pulse reading under the same conditions. However, the second pulse reading came after 3 min of gazing intentionally at the recently placed plants on their desks. The participants took these paired pulse rate readings throughout the entire experimental period.

Before the beginning of the study, the participants received an explanation of how to take their own pulse readings, and they practiced this several times. The 3-min time interval between the paired readings was determined by referring to a study by Ulrich et al. (1991) that used the pulse heart period, which is the reciprocal of heart rate, as a stress measure. In their study, it was reported that after a 10-min exposure to a stressor, the participants' heart rate decreased dramatically within 3 min when viewing a natural videotape. In our study, we needed to consider the minimum effective experimental time in order not to overstress the participants during their work, so we adopted Ulrich's established time frame.

To verify and supplement the data from the pulse readings and the STAI, we asked the participants to provide us with written feedback using a self-completed open-ended questionnaire at the end of the experimental period. Multiple answers were accepted.

Plant materials

Each participant chose one type of indoor plant to be installed on the desk. As shown in Fig. 1, the participants were offered a choice of six different types of plants: air plants (*Tillandsia pseudobaileyi*), bonsai of japanese cypress (*Chamaecyparis obtusa*) or japanese black pine (*Pinus thunbergii*), san pedro cactus (*Trichocereus pachanoi*), foliage plants [parlor palm (*Chamaedorea elegans*), heartleaf philodendron (*Philodendron oxycardium*), or garden croton (*Codiaeum variegatum*)], kokedama of corn plant (*Dracaena fragrans*), and echeveria [peacock echeveria (*Echeveria peacocki*) or *Echeveria* 'Splendor']. Bonsai is a Japanese plant artform that uses cultivation techniques to grow a tree in miniature. Kokedama is a Japanese planting style that consists of a plant and a ball of soil covered with moss. Three participants chose air plants, seven chose bonsai, five chose cacti, 15 chose foliage plants, 11 chose succulent plants, and 22 chose kokedama.

The plants were about 15 to 20 cm high, measured from the surface of the desk to the top of the plant. All plants were about 7 to 10 cm wide, which left enough working space on the desk. The size of the plants was determined by referring to a study by Hasegawa and Shimomura (2009). They indicated that insufficient space for placing plants on desks might have caused negative effects on the office worker, such as a feeling of pressure.

Two days after an oral and written explanation of how to water and care for the plants, each participant chose one favorite plant. They were told to put the plant on their desk, near their PC monitor, so they could always see and take care of the plant (Fig. 1). When a plant chosen by a participant withered during the course of the study, it was replaced with another of the same type of plant immediately. Although the plants were not offered as incentives, at the completion of the study we gave the plants to all participants who desired to keep them.

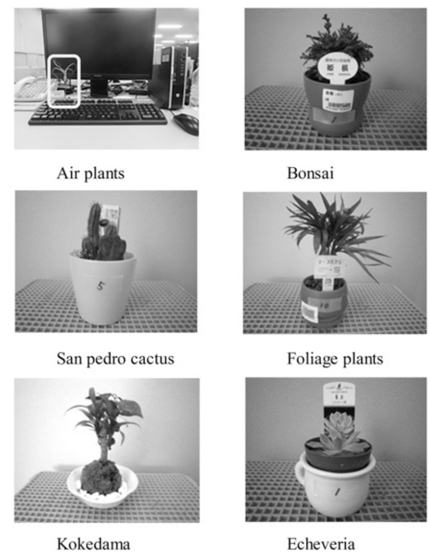

Fig. 1. Types of distributed plants and installation environment during the intervention period. Each participant chose one of six types of small indoor plants and placed it near the PC monitor on their desk, as shown in the top-left picture. Bonsai is a Japanese plant artform that uses cultivation techniques to grow a tree in miniature. Kokedama is a Japanese planting style that consists of a plant and a ball of soil covered with moss.

Statistical analyses

Statistical analyses of the data from the STAI scores and pulse rate were performed using a spread sheet (Excel 2010; Microsoft, Redmond, WA) with add-in software (SSRI version 1.02; Social Survey Research Information Co., Tokyo, Japan). Cross-tabulation analyses were performed using statistical software (IBM SPSS Statistics version 24; IBM Corporation, Armonk, NY). The normality of the data for the STAI scores (male, female, and overall) before and after the intervention, and that of the individual pulse rate before and after the 3-min rest was first assessed using the Shapiro-Wilk test. The Shapiro-Wilk analysis did not show a normal distribution within all groups; therefore, we decided to use the nonparametric methods for comparison of the STAI scores before and after intervention and also for the comparison of individual pulse data before and after the 3-min rest.

STAI data. We used the two-sided Wilcoxon signed rank test ($P < 0.05$) to compare the STAI scores after the control period (without plants) and after the intervention period (with plants). In addition, we compared the STAI scores between the male and female groups pre- and postintervention using the two-sided Mann Whitney *U* test ($P < 0.05$). To examine the effect of age on STAI scores, we divided the participants into four age groups (20–29, 30–39, 40–49, and 50–59 years) and compared the changes in the STAI scores using Scheffe's multiple comparison test ($P < 0.05$). We also looked for effects from specific plants on the changes from pre- to postintervention STAI scores by dividing the participants into six groups according to the type of plants they chose. We used Scheffe's multiple comparison test ($P < 0.05$) for multiple comparison.

Pulse rate data. We investigated the pulse rate trends of each participant taken during the control period and during the intervention period using the two-sided Wilcoxon signed rank test ($P < 0.05$).

To compare the proportion of each trend (a significant decrease, no significant change, and a significant increase) during the control period and the intervention period, we used two-sided two-sample tests for equality of proportions without continuity correction ($P < 0.05$). We investigated the potential effects that the different plants chosen might have had on the changes in pulse rate during the intervention period. For this, we performed cross-tabulation analysis with Fisher's exact test ($P < 0.05$) between the six types of plants and the pulse rate measurements.

STAI and pulse rate comparison. To investigate the relationship between the changes in pulse rate and those in the STAI scores during the intervention period, we performed cross-tabulation analysis with Fisher's exact test ($P < 0.05$). Before performing cross-tabulation analysis, we sorted the changes in the pulse rate into three categories according to the results of the statistical analysis using the two-sided Wilcoxon signed rank test at the 5% level of significance.

Results

STAI trait anxiety scores

Table 1 shows the changes in the STAI scores between pre- and postintervention period measurements. The two-sided Wilcoxon signed rank test revealed a significant decrease from STAI scores measured before the intervention period to those measured after, among participants as a whole ($P = 0.022$), as well as in the male group alone ($P = 0.037$). As shown in Fig. 2, concerning all participants, those with "high" anxiety levels (defined by scores between 53 and 80 in males and scores between 50 and 80 in females according to the manual of the STAI Japanese version) decreased from 20 (31.7%) to 19 (30.2%) after intervention. On the other hand, those with "low" anxiety levels (defined by scores between 20 and 42 in males and scores between 20 and 39 in females), increased from 18 (28.6%) to 23 (36.5%) after intervention.

The two-sided Mann Whitney *U* test ($P < 0.05$) showed no significant difference in the STAI scores between the male group and the female group (before intervention, $P = 0.072$; after intervention, $P = 0.135$).

Participants' pre- and postintervention STAI scores were also compared by age group (20s, 30s, 40s, and 50s). Scheffe's test ($P < 0.05$) showed no significant difference among age groups, either among all participants or between the male and female participants considered as separate groups. Similarly, when participants were grouped by plant choice, Scheffe's test ($P < 0.05$) showed no significant difference in pre- and postintervention STAI scores relative to the plants chosen.

Changes in pulse rate

A decrease in pulse rate demonstrates sympathetic sedation and an increase in pulse rate demonstrates sympathetic excitement. As shown in Fig. 3, the two-sided Wilcoxon signed rank test ($P < 0.05$) demonstrated that during the control period, of the 63 participants, three participants (4.8%) showed a significant decrease and four participants (6.3%) showed a significant increase in pulse rate ($P < 0.05$). Fifty-six participants (88.9%) showed no significant change. During the intervention period, we found some important trends. Seventeen participants (27.0%) showed a significant decrease in pulse rate and nine participants (14.3%) showed a significant increase ($P < 0.05$). Thirty-seven participants (58.7%) showed no significant change.

The results of the two-sided two-sample tests for equality of proportions without continuity correction

Table 1. Intragroup comparison of the trait anxiety scores of the State-Trait Anxiety Inventory [STAI (Spielberger et al., 1983)] before intervention (without plants) and after intervention (with plants) by gender group.[z]

			Gender			
	All participants[y]		Male		Female	
Summary statistics	Before	After	Before	After	Before	After
Mean	47.9	46.2	50.1	48.1	45.6	44.2
SD	10.6	11.1	11.6	12.3	9.1	9.5
Minimum	26.0	23.0	26.0	23.0	34.0	29.0
Lower quartile	41.0	38.0	41.0	40.0	39.0	37.0
Median	47.0	47.0	50.0	49.0	43.0	41.5
Upper quartile	53.0	52.0	58.0	54.0	49.0	49.8
Maximum	77.0	79.0	77.0	79.0	66.0	68.0
P value[x]	0.022*		0.037*		0.254	

[z]Trait anxiety reflects a settled, pervasive tendency toward anxiety. We evaluated trait anxiety, using a scale for trait anxiety (Y-2) of the STAI, Japanese version [STAI-Form JYZ (Hidano et al., 2000)]. The possible range of scores is 20 to 80 and higher scores represent greater anxiety. A decrease in the scores indicates a reduction of anxiety.
[y]All participants experienced two phases: a period without plants and a period with plants (N = 63; 33 males, 52.4%; 30 females, 47.6%).
[x]The two-sided Wilcoxon signed rank test was performed for intragroup comparison of the changes in the STAI scores by gender group. An asterisk represents a significant difference of the *P* value, at $P < 0.05$.

demonstrated that the proportion of the significantly decreased pulse rate category in the intervention period was significantly greater than in the control period (P = 0.001). Correspondingly, the proportion of the category in which pulse rate showed no significant change was less during the intervention period than the control period (P < 0.001). There were no significant differences between the categories in which pulse rate increased significantly (P = 0.143; Fig. 3).

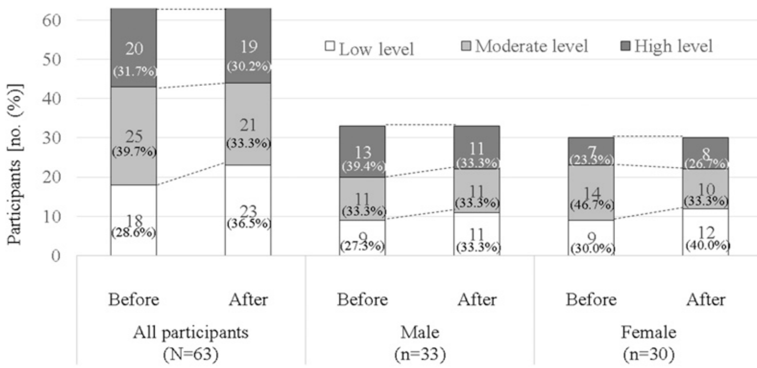

Fig. 2. Comparison of the distribution of all participants, male participants, and female participants at three levels of trait anxiety of the State-Trait Anxiety Inventory [STAI (Spielberger et al., 1983)] before intervention (without plants) and after intervention (with plants). The level of trait anxiety was classified by the total scores of a scale for trait anxiety (Y-2) of STAI. The range of total scores of the STAI Y-2 is from 20 to 80. Higher scores indicate greater anxiety. Criteria of the scores for the level of trait anxiety prescribed in the manual of the STAI, Japanese version [STAI-Form JYZ (Hidano et al., 2000)] are as follows: low level, 20 to 42 for males and 20 to 39 for females; moderate level, 43 to 52 for males and 40 to 49 for females; and high level, 53 to 80 for males and 50 to 80 for females.

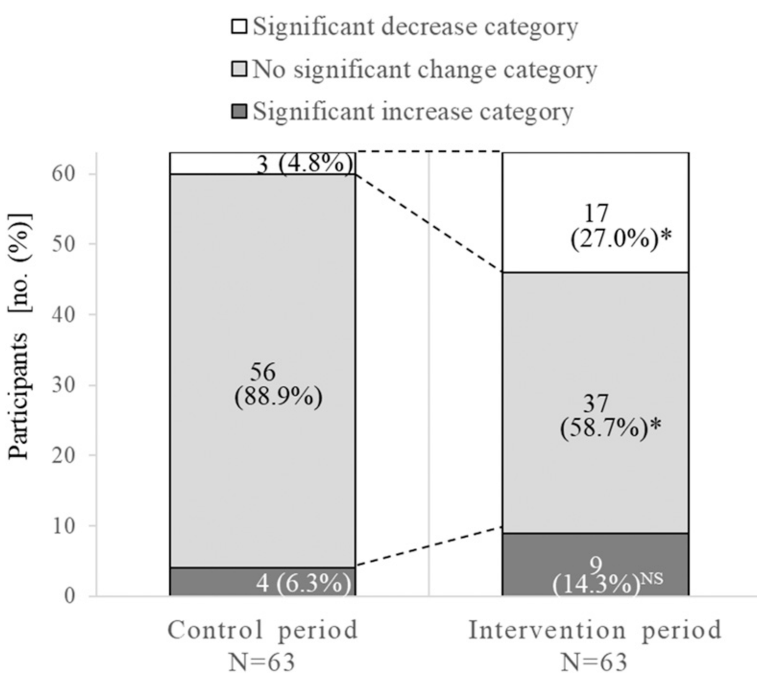

Fig. 3. Comparison of the distribution of participants by changes in pulse rate between the control period (without plants) and intervention period (with plants). We sorted changes in pulse rate into three categories according to the results of the statistical analysis using the two-sided Wilcoxon signed rank test at the 5% level of significance. An asterisk in the right column represents a significant difference in the variation of the proportion of each category based on the two-sided two-sample tests for equality of proportions without continuity correction (P < 0.05). NS indicates a nonsignificant change.

Cross-tabulation analysis with Fisher's exact test showed no significant association between the type of plants and trends in pulse rate measurements (P = 0.218).

Results of the cross-tabulation between STAI scores and pulse rate

Cross-tabulation analysis with Fisher's exact test showed no significant association between the STAI scores measured pre- and postintervention and changes in pulse rate during the intervention period (P = 0.338).

Feedback from the participants

Table 2 presents participants' comments concerning the benefits of the presence of plants on the desks. There were 38 comments submitted. Four participants provided two comments each, so 34 participants submitted positive feedback. The comments were classified into four main categories: psychological benefits, physical benefits, social benefits, and work environment-related benefits. The greatest number of comments related to psychological benefits (20 comments, 52.6%). There were 12 positive comments out of 23 participants who showed increased STAI scores.

Table 3 presents comments on troubles of having plants on the desk. There were 33 comments reporting some sort of trouble. One participant provided two comments; therefore, 32 participants submitted negative feedback. These comments were classified into five major categories related to growth of plants, outbreak of small insects, emergence of mold, practical management of plant cultivation, and knowledge of plant cultivation management.

Discussion

Psychological effects

The STAI scores decreased significantly from pre- to postintervention. The results did not differ significantly when we looked at the data within the age groups nor the different plant groups. These results suggest that placing small plants chosen by the participants within close sight of them contributed to their psychological stress reduction regardless of their age or plants choice.

Table 2. Summary of positive aspects of having a small plant on a desk according to the written feedback from the participants using a self-completed open-ended questionnaire[z] at the end of the experimental period.

Comments classified by changes in STAI scores (no.)[y]		Categories of the benefits of having plants on the desks				
		Psychological benefits	Physical benefits		Social benefits	Work environment-related benefits
		Watering was fun. Seeing my own plant growing was fun. Taking care of the plant was recreative.	Opportunities of walking for watering increased.	Opportunities looking aside from the PC monitor increased.	The number of coworkers talking with about plants increased.	The desktop got well organized (clutter free).
	no.	no. (%)[x]				
Decrease	22	12/22 (54.5)	1/22 (4.5)	3/22 (13.6)	3/22 (13.6)	3/22 (13.6)
No change	4	0 (0.0)	0 (0.0)	0 (0.0)	3/4 (75.0)	1/4 (25.0)
Increase	12	8/12 (66.7)	0 (0.0)	0 (0.0)	2/12 (16.7)	2/12 (16.7)
Total	38	20/38 (52.6)	4/38 (10.5)		8/38 (21.1)	6/38 (15.8)

[z]Multiple answers were accepted in the questionnaire.
[y]We classified the participants who gave positive comments into three groups according to the difference in State-Trait Anxiety Inventory [STAI (Spielberger et al., 1983)] scores before and after the intervention. A decrease in the score shows a decrease in trait anxiety; an increase shows the opposite.
[x]The denominator is the number of comments in each group classified by the changes in STAI scores. The numerator is the number of comments in each category of benefits of having plants on the desks.

There were 38 positive comments in total, such as "Seeing my own plant growing was fun" or "Taking care of the plant was recreational," including 12 comments from participants whose STAI scores increased (Table 2). As Nishina (2008) suggested, affection for a plant of one's own and having chosen it oneself may have played a role in the reduction of psychological stress. We provided an assortment of plants from which the participants could choose; however, the type of plants chosen had no effect on the changes in STAI scores. Our results suggest that the preference for a favorite plant overrides any influence that the differing species may have had on the reduction of psychological stress, which supports Nishina's conclusion.

No participants mentioned troubling issues regarding the work environment. Hasegawa and Shimomura (2009) reported that the lack of enough space for installing plants might produce stress. This did not arise as a factor in our study, despite locating the plants on the desktop. The small size of the plants used in the study was a strong factor in mitigating this outcome.

No significant relationship was detected between the changes in the pre- and postintervention STAI scores and the changes in pulse rate during the intervention period. This suggests that the participants whose pulse rate decreased did not coincide with those whose STAI scores decreased. Taking a 3-min rest in the morning and again in the afternoon, and also transferring the participants' gaze from the PC monitors to small plants increased the number of workers who benefited from temporal stress reduction. There were 38 positive comments out of 63 participants (Table 2). Four participants gave two comments each. This result indicates that newly added opportunities to view plants and to take care of the plants for 4 weeks had a positive impact on 34 participants (54.0%), regardless of the changes in STAI scores.

Physiological effects

In this study, 17 of 63 participants showed a decrease in pulse rate taken during the intervention period. This supports the findings of

Table 3. Summary of troubling aspects of having a small plant on a desk according to the written feedback from the participants using a self-completed open-ended questionnaire[z] at the end of the experimental period.

Comments classified by changes in STAI scores (no.)[y]		Growth of plants		Outbreak of small insects	Emergence of mold	Practical management of plant cultivation		Knowledge on management of plant cultivation
		The plant was not healthy.	The plant withered. (The plant died.)	Some small houseflies arose.	White mold grew in the soil.	Watering was bothersome.	Putting the plant in the sun was bothersome.	I had no idea how to water. I had no idea about the overall management of the plant cultivation.
	no.	no. (%)[x]						
Decrease	18	6/18 (33.3)	6/18 (50.0)	3/18 (16.7)	0 (0.0)	2/18 (11.1)	0 (0.0)	1/18 (5.6)
No change	2	0 (0.0)	0 (0.0)	0 (0.0)	1/2 (50.0)	1/2 (50.0)	0 (0.0)	0 (0.0)
Increase	13	4/13 (30.8)	1/13 (7.7)	1/13 (7.7)	0 (0.0)	3/13 (23.1)	2/13 (15.4)	2/13 (15.4)
Total	33	17/33 (51.5)		4/33 (12.1)	1/33 (3.0)	8/33 (24.2)		3/33 (9.1)

[z]Multiple answers were accepted in the questionnaire.
[y]We classified the participants who gave comments concerning troubling aspects into three groups with the difference in the f State-Trait Anxiety Inventory [STAI (Spielberger et al., 1983)] score before and after the intervention. A decrease shows a decrease in trait anxiety; an increase shows the opposite.
[x]The denominator is the number of comments in each group classified into three groups by the changes in STAI scores. The numerator is the number of comments in each category of troubles of having plants on the desks.

two previous studies. The first is the finding of Ulrich et al. (1991), who demonstrated that natural views decrease rapid pulse rate more effectively than viewing urban scenes. The second is the conclusion of the study by Choi et al. (2016) that "given a limited interior space, even a small amount of greenery may exert a relaxing effect on people" (p. 37).

As with the psychological stress data, the type of plant had no effect on the pulse rate. This suggests that the type of plant played no important role in physiological stress reduction, provided the plant is a favorite of the participants.

At this point, we want to consider why gazing intentionally at a plant decreased participants' pulse rate. During both the control period and the intervention period, the participants measured their pulse rate at their own desk. During both periods of the study, participants worked in front of a PC monitor and then took their pulse rate as soon as they felt fatigue. After gazing intentionally at the prescribed object for 3 min, they measured their pulse rate again. The only difference between the control period and the intervention period was what they looked at: the desktop or the plant of their choice. Ulrich et al. (1991) suggested that "content differences in terms of natural vs[.] human-made properties, rather than variations in stimulation levels, were decisive in accounting for the differences in recovery and intake/attention" (p. 225).

When we notice something, either directed or voluntary attention is necessary. Kaplan and Berman (2010) stated, "There exists widespread agreement that effort is an important component of voluntary or directed attention . . . . From an evolutionary perspective, effort would be expected to serve as a negative feedback mechanism . . . ." (p. 47). In this study, we cast a spotlight on the difference in the characteristics of two objects of attention. During the control period, the object of the participants' attention during the rest was lifeless—documents, the phone, or the desk itself—all of which are likely to be associated with work-related thought. In contrast, the object of attention during the intervention period rest was a living plant. This natural object incorporates elements that may induce comfortable feelings, such as vitality, beauty, affection, and so on, which is speculated to be helpful in getting away from work-related thought. Gazing at a plant creates separation from stressors and provides the participants opportunities to remove themselves from the strain of work, if only for a few minutes each time. The increase in the number of the participants who showed a decreased pulse rate during the intervention period could be attributed to the quality of the objects of attention. From the perspective of the attention restoration theory, Kaplan and Berman (2010) mentioned that "soft fascination is so pertinent to recovery" (p. 49). A plant on the desk in our study provided the opportunity for soft fascination in the office environment.

Beneficial aspects of having plants

There were 20 comments (52.6%) related to psychological benefits regardless of a decrease or an increase in the STAI scores of the participants who gave positive comments (Table 2). This means the psychological benefits from plants were easier for the participants to understand and express compared with the benefits in other categories [physical benefits, four comments (10.5%); social benefits, eight comments (21.1%); and work environment-related benefits, six comments (15.8%)]. Even among the participants who did not mention benefits other than psychological ones, there might have been some participants who received other benefits. We need to validate whether the participants realized these benefits by asking specific, concrete questions in a future study.

Troubling aspects of having plants

There were 33 comments reporting some sort of troubles (Table 3). Genjo and Matsumoto (2016) suggested the possibility that an adverse influence on the participants' state of mind could be caused by the deterioration of the plants. In our study, there were 17 comments on troubles concerning growth of plants, such as "The plant was not healthy" and "The plant withered." Twelve of 17 comments were given by the participants whose STAI scores decreased. Deteriorated plants did not have a very profound effect on participants' psychological stress. One possible reason for the minimal impact of poor plant health was that we had prepared substitute plants in case of plant deterioration, and replaced the damaged plants quickly with the substitutes.

When we think of implementing plants in real office settings in the future, provision of plants chosen specifically to thrive in the particular office environment, preparation of substitutes for replacement, and the provision of additional cultivation knowledge to increase the skill level of the office workers should be required.

Conclusion

In our study, three levels of involvement with plants were introduced into the work environment. The first was passive observance of the presence of greenery on the desktop, the second was the prescribed activity of gazing at the plant, and the third was the physical activity involved in choosing and then caring for the plant. The presence of plants is generally considered to contribute to the improvement of the office environment. The passive observation of these plants is an easy way for office workers to access some degree of stress reduction. However, we suggest that the level of restorative benefit from passive observation of plants may lessen over time as the novelty wears off and interest in the static presence of a plant diminishes.

We, therefore, focused our study on the two active levels of involvement with plants: 1) prescribed gazing and 2) individual plant choice and care. Intentional gazing at the plant was a form of active involvement without major body movement. The participants in the study gazed at their own plant for 3 min when they felt fatigue. This behavior provided the time to divert their attention away from office tasks and toward the living plant. Cited in the literature review are studies documenting a reduction of perceived stress during periods of soft fascination nature viewing. Our findings in the workplace support, and are supported by, these studies. The results suggest that if employers would provide active encouragement for workers to take 3-min "nature breaks," the mental health of their employees would improve.

Less reported in the literature is the third level of involvement with the plants that was incorporated into this study: the active body movements and cognition required to care for a personally chosen plant. By choosing a favorite plant and taking responsibility for its care, the interactive relationship between the participant and the plant likely prompted a degree of affection. The indications are that the development of a mild attachment to the plant contributed to a greater level of participant involvement with the plant. This slight but meaningful emotional involvement could maintain interest over time and potentially intensify the restorative benefit of the placing a small plant on a desk.

Further research on various nature-based methods of stress reduction and the related effects on other workplace outcomes—such as attention capacity, task performance, and productivity—is necessary.

For business owners, small indoor plants could be economical and helpful in their effort to reduce stress-related conditions. In addition, for growers of indoor plants and business owners of rental plant companies, the field of mental health for office workers could be promising markets. Our findings provide a piece of evidence in using small indoor plants for promoting workers' mental health in the office.

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