

Learning Performance in Odor Environment with aroma oils: Influence of Odor of Essential Oils on Learning Performance in Classroom

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ABSTRACT

There is no doubt that odor is also an important factor to evaluate indoor air quality. Since the olfactory system was proven to be closely related to the limbic structures which support emotion, long-term memory and motivation, the psychological and the physiological effects of the essential oils have been widely researched in various fields. The odor environment formed by essential oils is popularly used in commercial facilities to make customers have special mood. On the other hand, there are also some studies about its effects on workplace productivity or learning performance in actual spaces such as office buildings and schools.

The purpose of this research is to examine whether the odor environment with essential oils has positive effects on learning performance in classroom and how students feel about the environment. In this paper, the influences of "rosemary" essential oil on learning performance and mood in healthy participants are tested. Participants were all graduate or undergraduate students and were divided into two groups randomly and assigned to conditions of rosemary aroma or no aroma (control).

Learning performance was assessed using two methods, and one is reading task and the other is verbal memory task. The number of letters participants read during the specified time and a percentage of correct answers of the comprehension test were used to evaluate the performance in reading task. For verbal memory task, Esperanto words were adopted. In order to assess memory retention, these tests were conducted again about one month after the first task unexpectedly for the same participants. Additionally, the subjective evaluations were done by participants before and after tasks with several mood scales: intensity of odor, hedonic scale, preference, acceptability of odor environment, evaluation of impression on odor and impression of experimental room.

As a result, under the condition of rosemary aroma, the number of letters in reading task was significantly larger than control group without aroma odor. From the t-test, however, there was no significant difference between two samples in terms of memory retention. Analysis of subjective evaluation revealed that the mood of participants is greatly affected by the preference of the odor of rosemary aroma. It was found that the participants tend to select negative words among many SD scales for odor they dislike in the impression evaluation of odor.

KEYWORDS

Odor, Sensory Evaluation, Rosemary, Learning Performance

1 INTRODUCTION

Indoor climate affects individual performance [1]. It is known that poor indoor environment derived from high indoor temperature and low ventilation rate has a negative effect on working performance [2, 3]. As improving workplace productivity is directly related to the economic benefit, the influence of indoor environment on performance in office work has been widely studied. On the other hand, there are relatively fewer studies on learning performance in school.

Wargocki et al. [4] examined children’s learning performance under different temperature and ventilation rate conditions. As a result, it was proven that increasing the outdoor supply air rate and appropriate temperature can improve the performance of schoolwork. Like temperature, humidity and ventilation rate, odor is also an important factor to evaluate the indoor environment. However, the influence of odor on learning performance is still not well understood. Since it was revealed that the olfactory system is directly connected to the limbic structures which are known to control human’s mood and memory, the effects of the odor environment have been actively discussed and studied recently. Although there are some studies about its effects on office productivity [5], little information exists concerning its effects on learning performance in study spaces.

This research investigates whether the odor environment has positive effects on learning performance of university students and how students feel about studying in an environment fragranced by essential oils. In this paper, the influence of "rosemary" essential oil, which is known to improve memory and concentration [6], on learning performance and mood are investigated using two tasks; reading task and verbal memory task. Subjective evaluation is also analysed considering preference for the odor.

2 EXPERIMENT

2.1 Participants

Participants were comprised of seventeen males and fourteen females, healthy university students, aged 19-26 years (mean age, 21.7 ± 1.9 years). All the recruited participants were engineering majors in order to reduce individual effect due to knowledge differences. Thirty-one participants were randomly assigned to one of two groups: a group under the odor environment with rosemary essential oil (Rosemary), and a control group using water vapor (No Atomizing). All of them were non-smokers and passed the screening test of using five kinds of standard odor (“T&T olfactometer”: the standard olfactory test for selecting participants in Japan), and they received reward for participating in the experiments. Experimental conditions are shown in **Table1**.

Table 1: Experimental conditions

	Number of Participants						Elapsed Days	
	First Test			Second Test			Average	Min / Max
	Male	Female	Total	Male	Female	Total		
Control (No Atomizing)	7	8	15	7	7	14	38.9	31 / 44
Rosemary	10	6	16	7	5	12	40.2	37 / 44

2.2 Experimental setup

The experiment was carried out in the meeting room of Osaka University from December 2018 to February 2019. A heat exchange ventilating unit (100 m³/h airflow rate from the catalog value) and a packaged air conditioner were installed on the ceiling. In order to distribute the aroma odor evenly in the whole room, four circulators were placed at the four corners of the room, and the aroma diffuser was set on one of the circulators (**Fig.1**).

The detailed time schedule for each experimental session is shown in **Fig.2**. Aroma atomization from the diffuser was started twenty minutes in advance of experiment. The participants were given instructions outside the room and started subjective evaluation right after they entered the room.

In this experiment, Rosemary cineole (produced by Tree of Life Corp.) was used to provide the odor environment. Rosemary was chosen for its effects of enhancing memory and concentration. Rosemary essential oil was atomized for 10 seconds in every minute, from the nebulizing aroma diffuser.

Due to the concern that the thermal environment affects learning performance as well, PMV was measured using PMV meter (AM-101 manufactured by Kyoto Electronics Manufacturing CO., Ltd). CO₂ concentrations were also measured by portable CO₂ recorder (TR-76Ui manufactured by T&D Corp.), to make sure that the room air was mixed evenly.

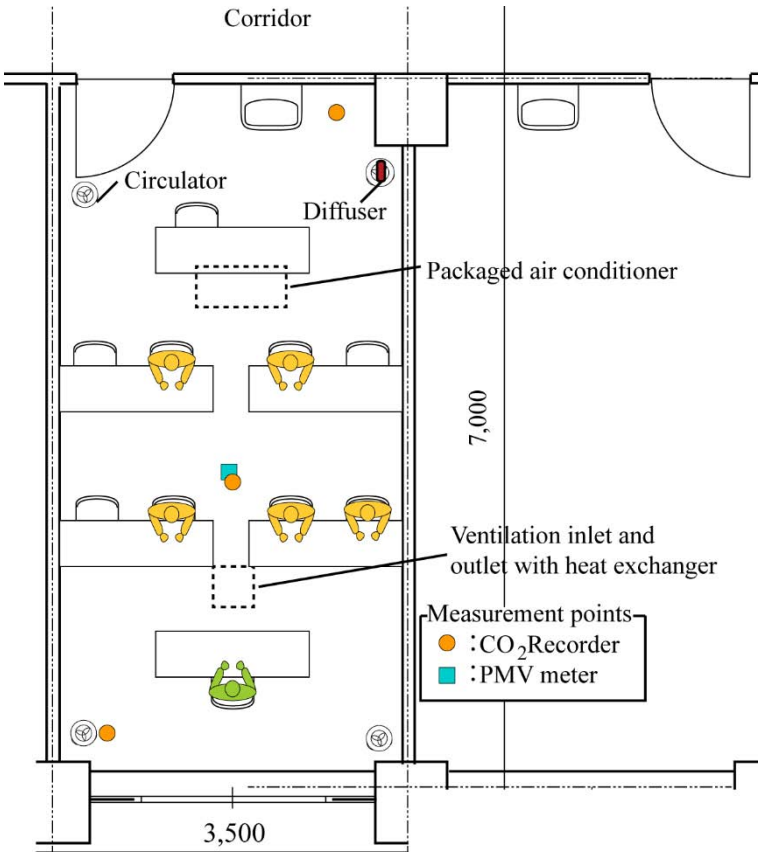


Figure 1: Plan view of the experimental room

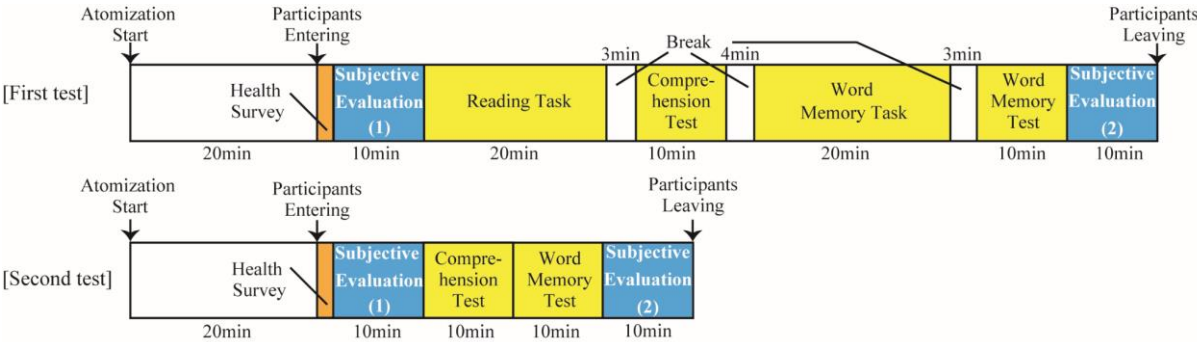


Figure 2: Experimental time schedule

2.3 Subjective Measurements

The questionnaire was used to obtain subjective evaluation included questions regarding perceived odor environment. All items of the questionnaire are shown in Fig.3. The perceived odor environment assessed using categorical scales describing the intensity of odor, odor pleasantness, preference, and impression of odor. In addition, acceptability of odor environment and acceptability assuming that participants study in the lecture room with the odor environment for 90 minutes were also assessed.

The odor intensity was measured using the 6-point category scale, and odor pleasantness and preference were measured using the 9-points category scales [7]. Both acceptability of the odor were assessed using continuous scales [8,9]. The twenty-one sets of odor impression were measured by Semantic Differential (SD) scale method with 7-points category [7]. All scales were presented in Japanese in the experiment.

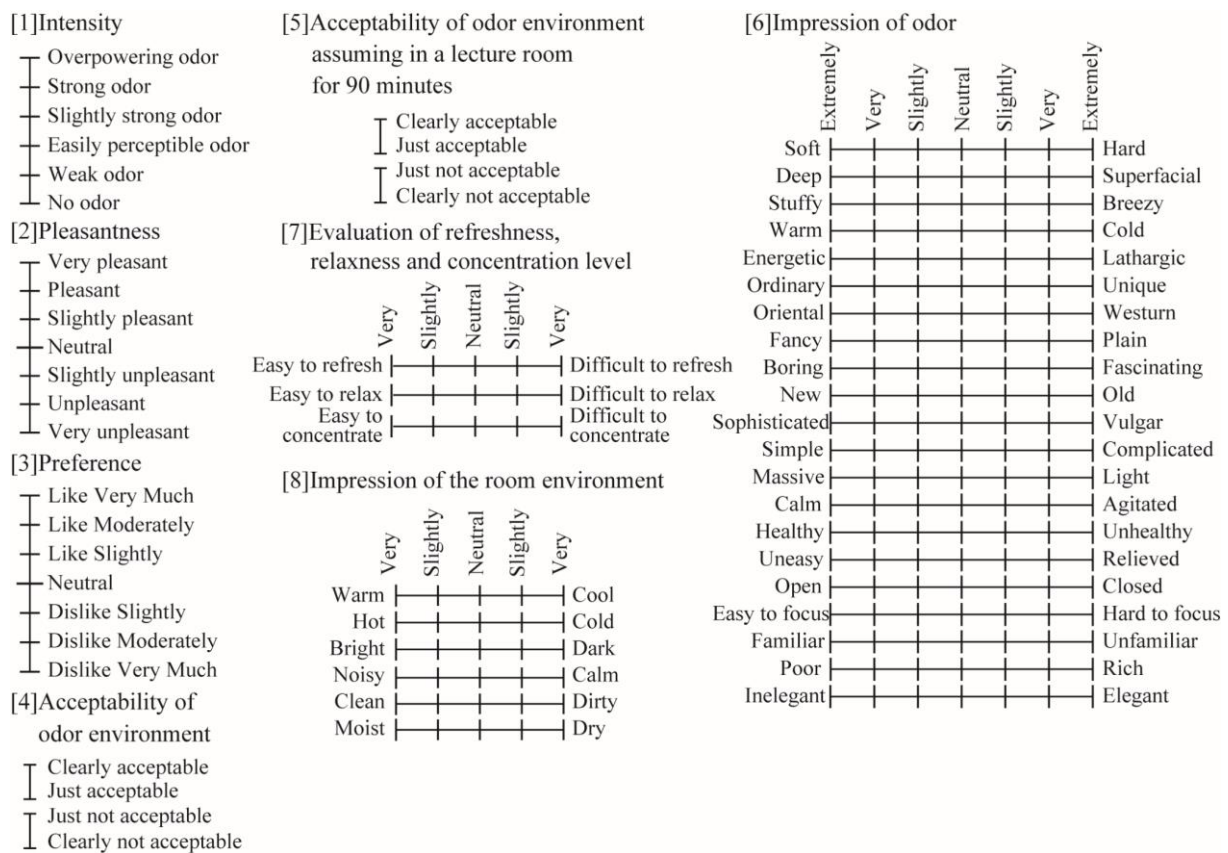


Figure 3: Scales for subjective evaluation

2.4 Subjective Measurements

Two types of tasks which simulated actual learning behaviors were adopted to evaluate the learning performance: a reading task and a memory task [10, 11]. The reading task was assessed by how many letters participants could read in 20 minutes and the score of comprehension test. Even though the answer was correct, it was not counted toward the score if the question was from the unread part. In addition, five-option two-choice questions were used to avoid a lucky guess.

The verbal memory task was evaluated by the score of vocabulary quiz. The Esperanto vocabulary list of 69 words and Esperanto dialogue with Japanese translation was offered to every participant. Participants memorized the vocabulary list for 20 minutes and took the word memory quiz. The Esperanto language was selected because it is written in alphabets and participants are less likely to have studied this language before. During the task, participants

were not informed what language it was. After the task, participants answered the question of what language it was. One participant knew about the Esperanto language and the data of the participant was excluded from the evaluation.

In order to examine the influence on memory retention, after a month, participants retook the same tests without being informed in advance. Maximum, minimum and average elapsed days from the first test to the second test are shown in **Table 1**.

3 RESULT AND DISCUSSION

3.1 Odor Intensity, odor pleasantness, preference and acceptability of odor

The measured results of odor intensity, odor pleasantness, preference and acceptability of odor are shown in **Fig.4(1)**. It was assumed that the preference of the odor would affect subjective evaluation; hence, the “Rosemary” group was further classified into two subgroups: a group of participants who like the scent of rosemary (“like” group, N=9) and a group of participants who dislike it (“dislike” group, N=5). The mean value of the Rosemary group tends to be close to neutral compared with control group. However, it was revealed that there were significant differences between evaluation of the “like” group and the “dislike” group. The “like” group evaluated the odor environment produced by the rosemary essential oil as more pleasant and more acceptable. In the second subject evaluation, all results got close to neutral. Olfactory adaptation could be the reason.

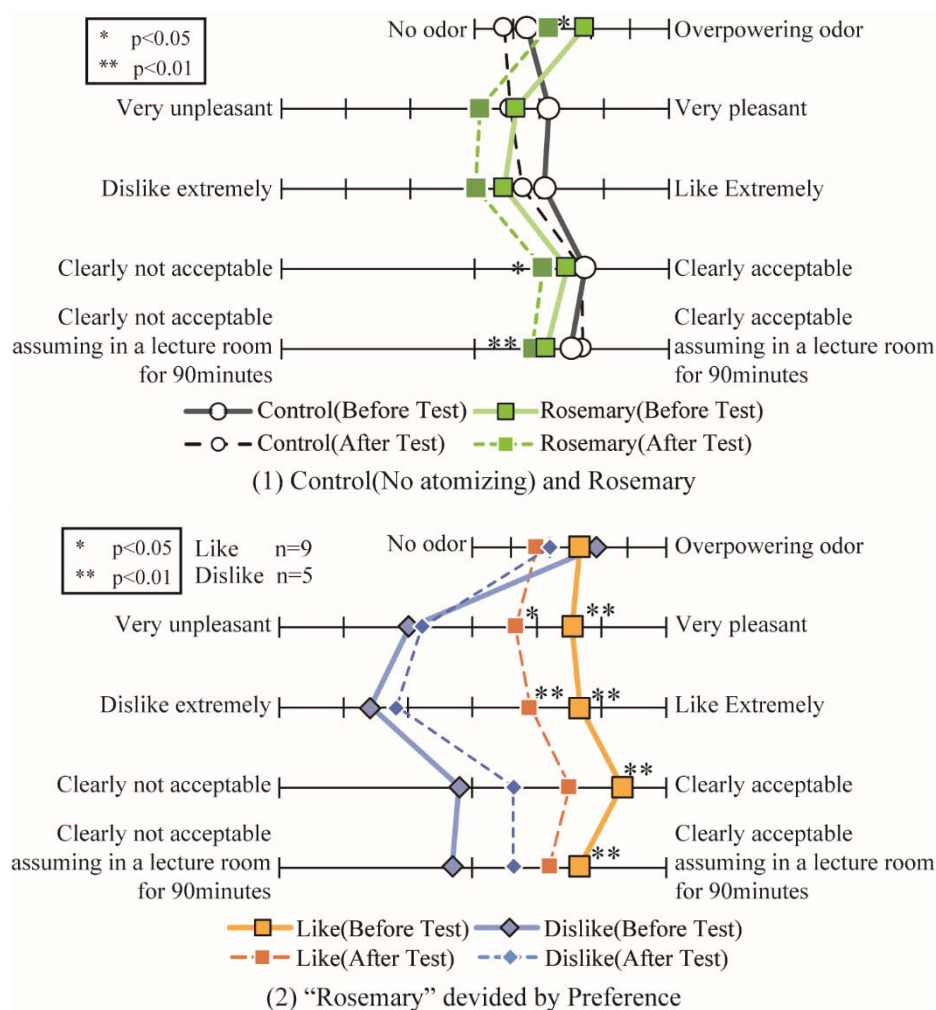


Figure 4: Intensity, Pleasantness, Preference and acceptability of odor. The results of the t-test are indicated by “*” for 5% statistical significance and by “**” for 1% statistical significance in figures.

3.2 Percentage of dissatisfied

Percentages of dissatisfied (PD) were calculated using the evaluations on the acceptability scale. PD of the rosemary odor in the environment itself, as well as assuming learning in a lecture room with an odor, are shown in **Fig 5**. The environment with the odor of rosemary tends to be acceptable. However, PD increased when it was assumed that the rosemary odor exists in the lecture room. Participants may feel that studying in the room under the aroma environment is an unfamiliar situation. PD for both questions decreased with each subjective evaluation. One reason for decreasing of PD was that there were fewer participants in the second test than in the first test. Another reason could be the influences of olfactory adaptation and habituation.

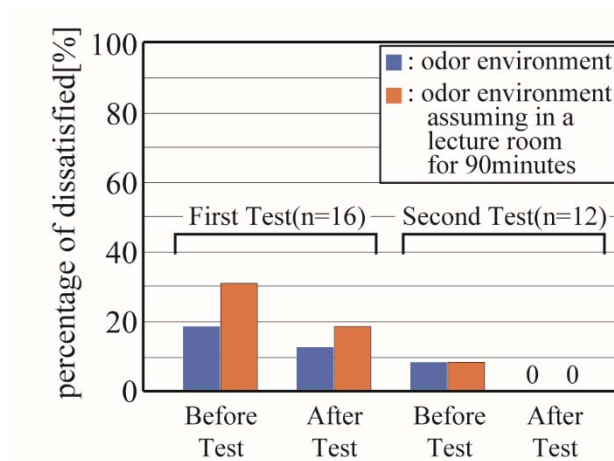


Figure 5: Percentage of dissatisfied of rosemary

3.3 Percentage of dissatisfied

The impression of the odor in the experimental room was evaluated using the SD method (**Fig. 6**). There were significant differences between the control and rosemary groups in the adjective pairs of “Energetic-Lethargic”, “Unique-Ordinary”, “Plain-Fancy”, “Simple-Complicated” and “Easy to focus-Hard to focus”. It was also revealed that the preference for the odor considerably affected the impression of odor. In most of the adjective pairs, the “like” and “dislike” groups selected opposite sides. The participants who liked rosemary tended to have a more positive impression than those who disliked it. However, interestingly, concerning the adjective pair “Unique-Ordinary,” both the “like” and “dislike” groups considered rosemary odor slightly unique.

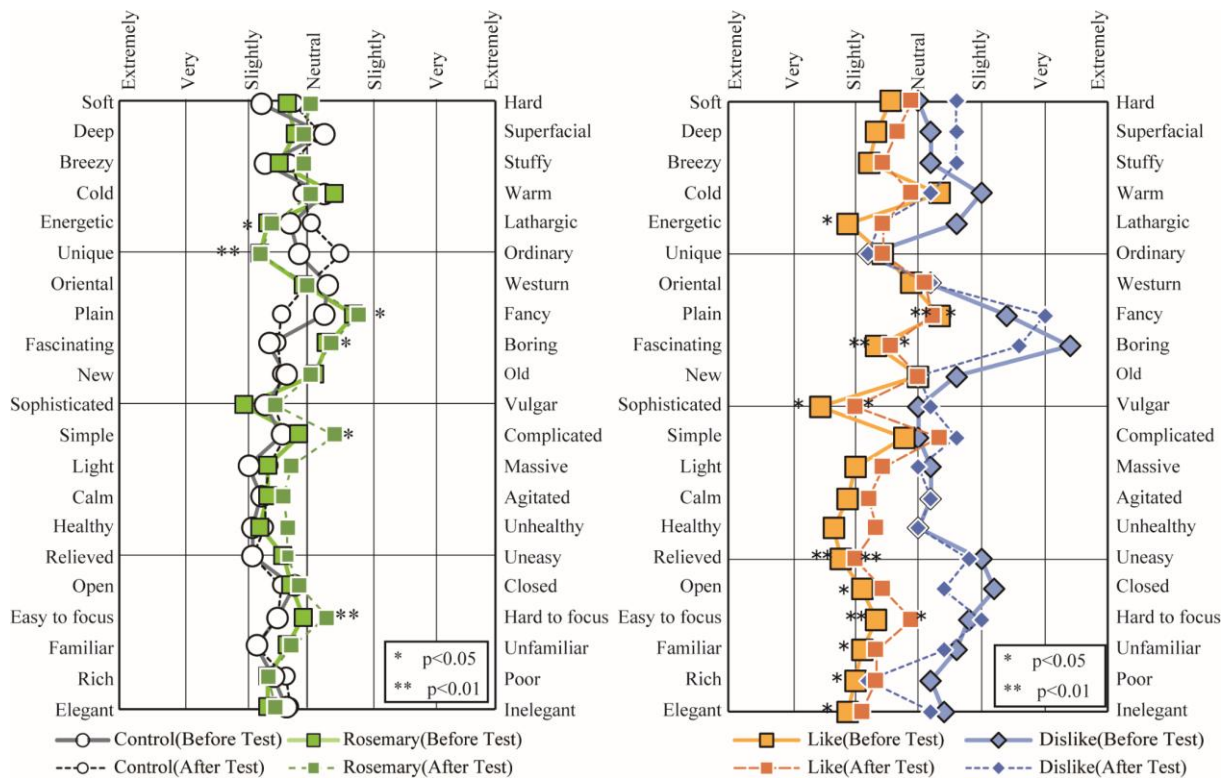


Figure 6: Impression of odor. The results of the t-test are indicated by “*” for 5% statistical significance and by “**” for 1% statistical significance in figures.

3.4 Impression of the room environment

As shown in Fig.7, the impression of the room did not differ significantly between control and rosemary groups. Participants, however, who dislike rosemary evaluated the experimental room as hotter and dirtier compared with participants who like rosemary in the first subjective evaluation (Before test). However, there was no significant difference in the second evaluation (After test). The odor may not make a considerable difference to the impression of the room, especially in terms of light and acoustic environments.

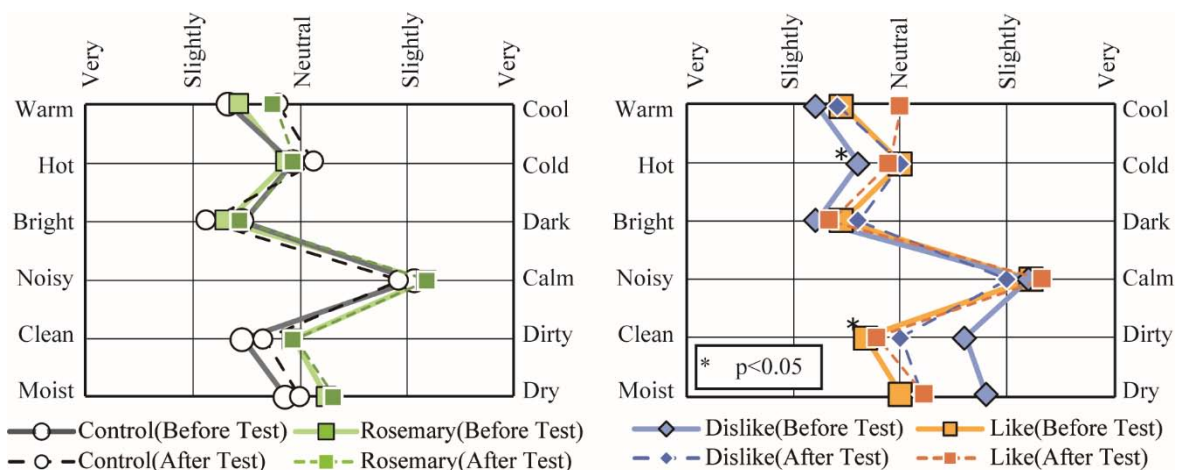


Figure 7: Impression of the conference room. The results of the t-test are indicated by “*” for 5% statistical significance and by “**” for 1% statistical significance in figures.

3.5 Impression of the room environment

Fig.8 shows the subjective evaluation results of the impression of odor environment. The mean value of the rosemary group was close to neutral in every item. However, considering the preference for the odor, participants who like the rosemary odor evaluated the odor as easier to refresh, relax, and concentrate than the “dislike” group. The results indicate that the preference for the odor has a great influence on how people feel and act.

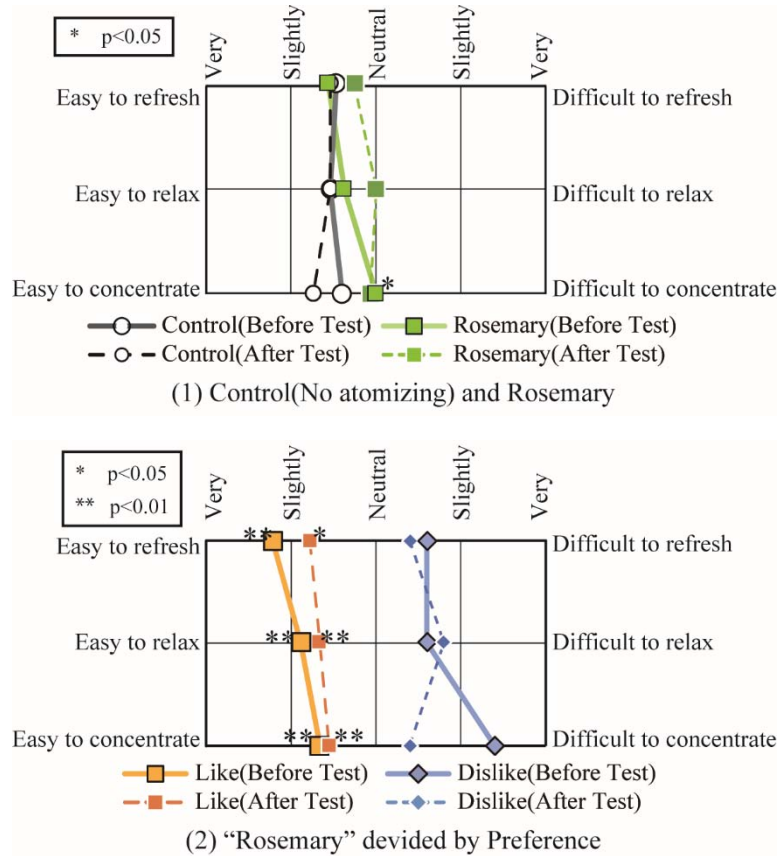
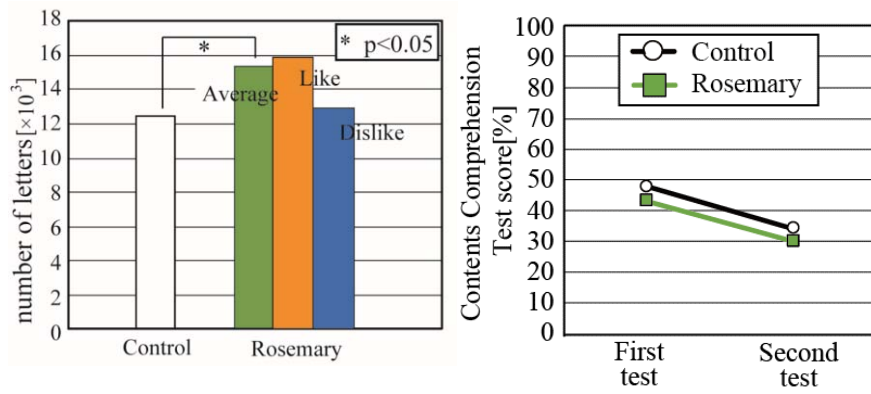


Figure 8: Impression of the odor environment. The results of the t-test are indicated by “*” for 5% statistical significance and by “**” for 1% statistical significance in figures.

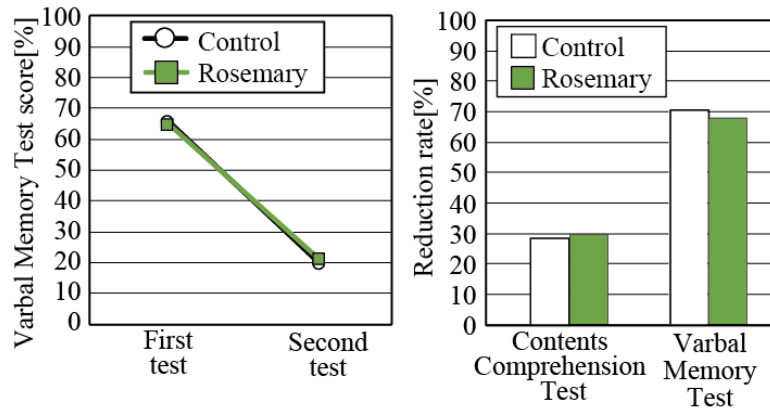
3.6 Tests Score

Test scores of two methods are shown in **Fig.9**. The rosemary group read a larger number of letters than the control group ($p<0.05$). However, there was no significant difference in the correct answer rate of the comprehension test after reading between two conditions (**Fig.9(2)**). The result indicates that the rosemary group could read faster than the control group without decreasing the comprehension level. Furthermore, the average number of read letters was larger with the “like” group, compared with the “dislike” group. Hence, the preference for odor may also influence reading speed.

On the other hand, there was no difference between the rosemary and the control group in terms of the scores of the verbal memory test (**Fig.9(3)**). **Fig.9(4)** presents the measured results of the memory retention rate, which is the ratio of the second test score to the first test score. The average scores of two groups (rosemary and control) were nearly equal in the two tests. The odor environment of rosemary hardly had an effect on both short-term and long-term memories in this experiment.



(1) Number of letters (2) Test score: Reading task



(3) Test score: Verbal Memory (4) Memory retention rate

Figure 9: The results of learning performance tasks

4 CONCLUSIONS

- In this experiment, the reading speed of the rosemary group was faster than the control group, without any effect on reading quality. Rosemary essential oil may have a positive effect on enhancing concentration.
- There were no significant differences between rosemary and control groups in terms of memory retention.
- The preference for the odor affects the impression of the odor environment greatly. Participants who like rosemary tend to evaluate the odor environment positively.
- The percentage of dissatisfied decreased during the experiment, and the possible reason could be the influence of adaptation and habituation.

5 ACKNOWLEDGEMENTS

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