The Effect of Lemon Fragrance on Simple Mental Performance and Psychophysiological Parameters during Task Performance

Rieko KAWAMOTO¹, Chiharu MURASE¹, Itsuko ISHIHARA², Miharu IKUSHIMA²,
Junko NAKATANI, Miki HARAGA² and Jun SHIMIZU¹
¹ Department of Nursing Science and Arts, School of Health Sciences, University of Occupational and Environmental Health, Japan. Yahatanishi-ku, Kitakyushu 807-8555, Japan
² Department of Public Health and Occupational Health Nursing, School of Health Sciences, University of Occupational and Environmental Health, Japan. Yahatanishi-ku, Kitakyushu 807-8555, Japan
³ Department of Psychology and Communication, Faculty of Communication Studies, Aichi Shukutoku University, Nagakute-cho, Aichi-gun, Aichi 480-1197, Japan

Abstract: The purpose of this study is to effectively utilize fragrance in order to form a comfortable working environment, for which we obtained necessary data. The subjects were 14 female students. We made them do addition work in laboratories with and without lemon fragrance, and investigated their task performances, physiological changes and mood conditions. Our results showed that, although the existence or nonexistence of fragrance did not affect their work efficiency, it was revealed that fragrance mitigated exhaustion and maintained vigor.

Key words: lemon fragrance, Kraepelin tests, autonomic nervous function, POMS.
(Received 17 August 2005, accepted 8 November 2005)

Introduction

In modern society, people are always exposed to stress due to complicated work environments and diverse human relationships. Stress affects the autonomic nervous function, endocrine system, immune system, etc., and can cause psychological and physical damage. Stress leads to unstable psychological and physical conditions, and accumulated fatigue and diminished concentration ability caused by chronic stress not only lower work efficiency, but also may increase mistakes and cause accidents. Accordingly, it is useful to create a comfortable environment where people can work comfortably, not only for the individuals but also for the whole workplace.

As a means to solve this problem, aroma therapy using fragrances is attracting attention. Studies in the past have made it clear that the feeling induced by aromas has an effect on the efficiency of mental work, and consequently contributes to increasing or decreasing the per-
formance level [1–3]. It is our opinion, therefore, that an effective use of fragrance will produce a comfortable work environment, thereby enhancing the performance level of work. There is a diversity of aromas, however, with respective impact on favorable or unfavorable mood changes as well as alertness levels. It is critical, therefore, to select a fragrance which appeals to a majority of people with an appropriate alerting effect on improving work efficiency [1–6]. Investigating fragrance preferences, we obtained the result that the preference for lemon fragrance was highest. Therefore, we investigated the effects of lemon fragrance on work performance and mind and body, by making the subjects do addition work in a laboratory with lemon fragrance. Specifically, we measured simple mental work performance (quantity of work and accuracy rate), physical indexes (brain wave, sympathetic/parasympathetic nerve functions, heart rate and blood pressure) and psychological index (Profile of Mood States: POMS). Our study is based on the results of the above investigation.

Material and Methods

Subjects

The subjects were fourteen female students without disorders relating to the olfactory system or circulatory system (average age: 19.4 ± 1.8 years old). They were informed orally and in writing of the purpose and contents of the experiment and their consent was obtained by signature.

Kinds of fragrances and presenting method

Lemon fragrance (pure essential oil: Timeridian, Inc. USA) was sprayed in the laboratory using a Phyto-aromatic ultra jet diffuser (Timeridian, Inc. USA), starting five minutes before the subjects' entry to the laboratory until the end of the experiment. In order to maintain a constant density of aroma constant, they were prohibited to open or close the doors.

The consistency and degree of the fragrance effects the human's mood and action. So, we investigated the consistency and agreeableness of the fragrance after the experiment under conditions with fragrance. The degree which sensed the fragrance was 7.17 ± 2.10 points on average out of ten points under conditions with fragrance. The subjects who favored lemon fragrance were 13 students, and the degree was 7.37 ± 2.22 points on average out of ten points.

Simple mental performance

Many researchers use the Kraepelin test as a tool of mental workload. Then, the Kraepelin test should be carried out for the work in this study. The process of addition entailed adding the adjacent figures of several columns and writing down the figure of the 1st digit of the results. Adding the figures of a row had to be completed in one minute.
The procedure was then repeated with the next row. A series of these adding calculations was performed for 15 minutes, and after a five minute break, the same calculations were restarted and continued for 15 minutes.

**Index of performance efficiency**

The index of work efficiency was the quantity of work (the number of answers) and the accuracy rate.

**Measuring index and measuring method**

**Brain waves**

Beta waves showing an alert state (15 ~ 23 Hz) and mid alpha waves showing concentrated relaxed state (9 ~ 11 Hz) among electroencephalogram (EEG) were taken as indexes. The brain waves of the frontal polar zone were continuously measured from the resting state before the start of work until after the end of the rest period using Mind Sensor II (Brain Function Research Center). Beta waves and mid alpha waves were analyzed every five minutes using a brain wave analyzing program by Mind Sensor II for Windows Version 4.0.

**Activities of autonomic nervous function**

The indexes for monitoring the autonomic nervous function under experiment are high-frequency components (HF, 0.15 ~ 0.40 Hz band), low-frequency components (LF: 0.04 ~ 0.15 Hz band), which are obtained by a spectral analysis of heart rate variability based upon electrocardiogram (ECG) waveforms, and heart rate (HR). HF value is assumed as the index of parasympathetic nervous function, and the ratio of LF/HF as that of the sympathetic nervous function.

Electrocardiogram was taken employing a bipolar lead method using a standard Mac Lab8ch (Mac Lab/8e V3.5 model of Bio Research Center Co.). ECG patterns were checked by calculating HF value and LF/HF value using the Heart Rate Variability of Mac Lab Application Note AN309C. The waveforms of aspiration were also measured by fixing a belt to the chest.

Blood pressure was measured on the upper arm of the non-dominant arm using an automated blood-pressure meter before and after the work and immediately after the end of the rest period, for a total of 5 times.

**Profile of Mood States (POMS)**

POMS [7] was conducted in order to investigate the effect of fragrance on mood before and after work. POMS is a questionnaire to evaluate mood. It consists of 65 questions and measures the 6 scales of Tension-Anxiety (T-A), Depression-Dejection (D), Anger-Hostility
Investigation before task (POMS) Fixing instrument (EEG, ECG) (before) Task (Kraepelin) Resting (Interval) (after) Task (Kraepelin) (after) Resting Removing instrument (EEG, ECG) Investigation after task (POMS)

Fig. 1. Experimental Protocol.

(A-H), Vigor (V), Fatigue (F) and Confusion (C).

Experimental methods
The experimental protocol is shown in Fig. 1. After POMS was conducted, the subjects put electrocardiogram electrodes on their chest, probes for brain wave measurement on their head and a manchette for blood pressure measurement on their non-dominant upper arm. After five minutes rest, they worked for 15 minutes, rested for five minutes, worked for 15 minutes and rested for five minutes. During that time, electrocardiogram and brain wave tests were conducted continuously. After the experiment, POMS was conducted again.

The size of the laboratory was 4 m width × 6 m length. The room temperature was 21～25℃ and humidity was 53～60%. The height of the chairs was adjusted to suit each subject. The experiments were conducted both under conditions with fragrance and conditions without fragrance, with the same subjects, at the same clock time on different days. Subjects were divided into two groups in order to ensure counterbalance.

The analysis of the data used the analysis of variance by Statistical Package for the Social Sciences (SPSS).

Results

Work performance
The quantity of work was 2039.5 ± 425.9 points on average under conditions without fragrance, and 2040.6 ± 330.5 points on average under conditions with fragrance. The quantity of work under conditions with fragrance was 1 point (0.05%) less than that under conditions without fragrance. The accuracy rate under conditions without fragrance was 97.6 ± 1.5%, and 96.8 ± 0.25% under conditions with fragrance, and that under conditions with fragrance was 0.8% less than under conditions without fragrance. This result shows that there is no significant difference in work efficiency between conditions with and without fragrance.
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Brain waves

The beta waves and mid alpha waves under conditions with fragrance had lower voltage values. Although it was supposed that the electrical activity of the neocortex of the cerebrum was stable, a clear relationship between fragrance and brain waves was not shown. The activity of the left brain grows when in good mood and that of the right brain grows when in bad mood [8, 9]. The electroencephalography used in this experiment, however, failed to clearly distinguish the wave patterns of the left and right brains, and therefore, analysis was not conducted.

Autonomic nervous function

The results of LF/HF measurement are shown in Fig. 2. LF/HF significantly increased at $P < 0.01$ during work compared with rest time. Its value with fragrance was lower at 1.50 on average than that without fragrance at 2.14. However, no significant difference was shown. As the value of LF/HF was more than 1, it was judged that the sympathetic nerve was more active than the parasympathetic nerve.

The results of HF measurement are shown in Fig. 3. HF decreased more significantly at $P < 0.05$ during working time than during resting time. Its value with fragrance is not lower than that without fragrance. There was no significant difference between the cases with and without fragrance.

The results of heart rate measurement are shown in Fig. 4. Heart rate increased more significantly at $P < 0.05$ during working time than during resting time. However, there was no significant difference between the cases with and without fragrance.

The results of blood pressure measurement are shown in Fig. 5 and 6. Systolic blood
pressure increased more after the working time than before working time, however, there was no significant difference. On the other hand, diastolic blood pressure wasn’t changed by work.
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![Diagram](image)

*Fig. 7.* The change of the scales of the POMS after the simple mental performance with and without fragrance.

- □: No fragrance, ■: Fragrance.
- T-A: Tension-Anxiety, D: Depression-Dejection,

**Psychological conditions**

The point differences of six mood scales before and after working time are shown in Fig. 7. There was significant difference between the cases with and without fragrance. The fatigue scale by work significantly decreased at $P < 0.05$ under conditions with fragrance. But, the vigor scale didn’t decrease significantly at $P < 0.05$ under conditions with fragrance.

**Discussions**

No difference was observed between task performance, as shown by quantity of work and accuracy rate, under conditions with and without fragrance. The LF/HF value, the index of sympathetic nervous function, was 2.14 on average under conditions without fragrance and it decreased to 1.50 on average under conditions with fragrance. A low value of LF/HF shows a relaxation of tension, therefore, the tension was relaxed by fragrance. The LF/HF value was more than 1 during the working time. It can be said that the pulse pressure rises, because systolic blood pressure was high and diastolic pressure lowered. The pulse also increased. Those indicate that the sympathetic nervous activity was higher than the parasympathetic nervous activity during the working time. In other words, the subjects were tense during the working time. However, the state of tension is considered to be relaxed by fragrance. In order to effectively carry out work, a moderate tension and concentration power are necessary. However, as excessive tension will lower work efficiency, increase mistakes and cause accidents, it is important to control tension.

On the other hand, HF value, the index of parasympathetic nervous activity, was lower...
during working time than during resting time, and it was higher under conditions of fragrance. The HF value is said to be lowered by stress, aging and diseases [10]. As the HF value did not show a significant decline under conditions of fragrance, it is considered that the fragrance contributed to relaxing tensions.

Although heart rate increased during working time, no difference of heart rate caused by fragrance was observed, and no difference of blood pressures caused by fragrance was observed either. There is a study result showing that autonomic nervous function does not fluctuate on the favorite fragrance from the unforgettable fragrance [11].

In this study, differences in the fatigue and vigor scales from stress of the work were observed. Because of fragrance, fatigue decreased and vigor was maintained among the six moods of POMS. The effect of fragrance can be obtained in simple mental performance.

In this study, we could not obtain a result showing that fragrance caused a remarkable improvement in work efficiency. There are several reports stating that lemon fragrance did not affect work efficiency [1, 6] and that rose fragrances curbed the increase of the number of errors, while lemon fragrance didn’t [6]. Thus, our future task is to conduct experiments based on a number of different fragrances.

The effects of lemon fragrance on work efficiency, mind and body were described above. This study shows that lemon fragrance relaxed stress of the sympathetic nerve function as well as relieving fatigue psychologically and preventing the decline of vigor. It is our opinion that these factors will contribute to develop a comfortable working environment.

Acknowledgment

This is a part of a study being supported by the special issue, “Development of Evaluation Indexes for Industrial Health Control in Order to Create a Comfortable Workplace”, conducted by the University of Occupational and Environmental Health, Japan. We sincerely acknowledge and appreciate the support by all those involved.

References

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レモンの香りが単純精神作業および心身におよぼす効果

川本利恵子1, 村瀬千春1, 石原逸子2, 生崎美春2, 中谷淳子2, 原賀美紀2, 清水道2

1産業医科大学産業保健学部第1看護学講座
2産業医科大学産業保健学部第3看護学講座
3愛知薬科大学コミュニケーション学科

要　旨：本研究は、実験場所環境の形成に香りの効果を有効的に活用するための基礎的なデータを得る目的で行われた。実験は、被験者である14名の女子学生おのおのに対して、レモンの香りのある実験室とレモンの香りのない実験室という2つの異なる環境下における単純算数作業の成績、生理的変化、気分変化を調べ、その差を比較検討した。実験結果は、レモンの香りは作業効率を変化させないが、疲労を軽減させ、活力の低下を予防することを示唆した。

キーワード：レモンの香り、クレベリン検査、自律神経機能、POMS.

J UOEH（産業医大誌）27（4）：305−313（2005）