

Effectiveness of Aroma on Work Efficiency: Lavender Aroma during Recesses Prevents Deterioration of Work Performance

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Abstract

The present study investigated whether exposure to aromas during recess periods affects work performance. Subjects comprised 36 healthy male students (mean age, 24.2 ± 2.2 years) who were randomly divided into three groups: (1) control group, not exposed to aroma during recesses; (2) jasmine group, exposed to jasmine aroma during recesses; and (3) lavender group, exposed to lavender aroma during recesses. All participants completed five work sessions performing a task requiring concentration on a computer monitor, with each session lasting 60 min. Recess periods of 30 min were provided between each session. To clarify the time at which work concentration was lowest, work performance for the control group was analyzed. Concentration was lowest in the afternoon period, where afternoon drowsiness is strongest. Comparison of the three groups for this time period indicated significantly higher concentration levels for the lavender group than for the control group. No such effect was noted for the jasmine group. Although lavender is a sedative-type aroma, use during recess periods after accumulation of fatigue seems to prevent deterioration of performance in subsequent work sessions.

Key words: afternoon period, concentration, jasmine, sedative-type

Introduction

Information regarding the effects of aromas on work performance has previously been obtained through introducing aromas during work performance. The sedative effects of lavender and the stimulating effects of jasmine have been reported using contingent negative variation (CNV; Walter, 1964) as an indicator by Torii *et al.* (1988). Since then, further studies have been conducted to investigate the effects of these two aromas on working efficiency. CNV offers a good reflection of frontal lobe activity on electroencephalography (EEG), increasing in excited states and decreasing in sedated states. The present study examined the effects of lavender and jasmine aromas on working efficiency in terms of sedative and stimulatory effects.

According to one report, subject calculation rates initially dropped while performing mathematical equations under exposure to lavender aroma (Ludvigson and Rottman, 1989). Conversely, another report found that subjects exposed to

lavender aroma displayed decreased inaccuracies in calculating arithmetical equations and character count equations compared to jasmine and control groups (Degel and Koster, 1999). The results of the former study may be interpreted as suggesting that the relaxing effects of lavender reduce cognitive function, whereas the latter results have been said to indicate that sedative-type lavender aroma might prove beneficial when the subject is overstimulated by stressful work. With tasks that require the subject to maintain concentration while looking at a monitor, performance precision can be maintained using either sedative-type muguet or stimulant-type peppermint aromas (Warm *et al.*, 1991). Furthermore, maintenance of performance during exposure to peppermint aroma has been verified (Sullivan *et al.*, 1998). In these reports, peppermint aroma is considered to function more directly by raising the level of stimulation in subjects, while muguet aroma functions to remedy conditions

such as fatigue, stress, and headache. In simple tasks using visual or auditory stimulation during exposure to lavender aroma, Millot *et al.* (2002) noted that efficiency decreased, and Yagyū (1994) reported that response time (RT) was increased compared to subjects exposed to jasmine aroma. Moss *et al.* (2003) also found that performance decreased in a task requiring attention or working memory during exposure to lavender aroma. These reports indicate that lavender aroma decreases stimulation level and exerts a suppressive influence under intense conditions where high levels of mental activity are required.

In the above reports, exposure to stimulant-type aromas during work generally raises performance rate (Warm *et al.*, 1991; Yagyū, 1994; Sullivan *et al.*, 1998). Conversely, many studies have reported that exposure to sedative aromas such as lavender decreases working efficiency. However, sedative aromas may increase the efficiency for certain subjects or in certain states, such as whether the aroma is considered pleasant or not (Degel and Koster, 1999). Numerous studies have examined the effects of aroma presentation during work, but as aromatherapy becomes more popular and commonplace, the roles of aromas in facilitating and enhancing the relaxing and refreshing effects of breaks from work seem worthy of attention. We hypothesized that the recuperative effects of aromas may be optimal at time periods where conditions such as fatigue and drowsiness have accumulated and work performance is lowest.

The present study examined participants performing “work” from 0930 to 1700, basically representing a typical working day. Subjects without exposure to aromas were used to identify the time at which work performance was minimal. In groups exposed to aromas during recesses, the effectiveness of aromas in improving work performance at this time was examined.

Materials and methods

Participants

Participants comprised 36 healthy male university students without any abnormalities in the sense of smell. The purpose and schedule of the experiment were explained, and written informed consent was obtained from each participant prior to study initiation. Participants were instructed to go to sleep by 2330 and wake up by 0630 starting 2 days before the experiment, to avoid special activities such as group activities (excluding university lectures), and not to come in fatigued or drowsy on the day of the experiment. Consumption of alcohol, cigarettes, or medications was prohibited from 2 days before the experiment, as was the use of hair spray or antiperspirants from 1 day before the experiment and consumption of caffeinated drinks on the day of the experiment. Furthermore, to decrease the practice effect, the work task was only practiced for 30 min on the day before the experiment.

Participants were randomly divided into three groups ($n = 12$ each): (1) control group (mean age, 23.8 ± 2.2 years), not

exposed to aroma during recesses; (2) jasmine group (mean age, 23.9 ± 2.2 years), exposed to jasmine aroma during recesses; and (3) lavender group (mean age, 23.8 ± 2.5 years), exposed to lavender aroma during recesses. Administration of the Yatabe–Guilford test and Cornell Medical Index health questionnaire prior to the day of the experiment identified no significant differences between groups with regard to participant characteristics, such as instability, cooperation, and activity, or health conditions, such as fatigue and digestive disturbance.

In the jasmine and lavender groups, the degree of participant preference for the assigned aroma was evaluated during the first recess. No significant differences in terms of participant preference were noted between these groups.

Aroma

Aromas were created using evaporative methods with essential oils for jasmine and lavender (Takasago Aromas, Tokyo, Japan). A tank maintained at constant temperature (37°C) was placed in each recess room. Within each tank was a beaker containing 0.1 ml of essential oil and 100 ml of distilled water. To maintain uniform concentrations of aroma throughout the room, evaporation was started 30 min before every recess and ventilation was performed for 30 min after each recess. Each recess room was 6 m^2 , with identical insulation conditions (room temperature, $17\text{--}22^\circ\text{C}$; humidity, $50\text{--}65\%$). The tank was located in the center of each room, and participants were seated in a circle 1 m from the outer edge of the tank during each recess.

Experimental schedule

The time schedule is shown in Table 1. Briefly, participants performed five sessions of work (Sessions 1–5) between 0930 and 1700, with each work session lasting 60 min. Work sessions were separated by a 30-min recess (Recesses 1–4), with aroma presentation for 20 min during each recess. Lunchtime was from 1200 to 1230, after Session 2 and before

Table 1 Time schedule

Time	Work
0930–1030	Session 1
1030–1100	Recess 1
1100–1200	Session 2
1200–1230	Lunch
1230–1300	Recess 2
1300–1400	Session 3
1400–1430	Recess 3
1430–1530	Session 4
1530–1600	Recess 4
1600–1700	Session 5

Recess 2. All participants worked in the same area but went to group rooms at recess. Participants were not allowed to sleep during recess periods.

Work

During each work session, participants worked with a computer monitor using the same UNI performance efficiency assessment software used by Araki *et al.* (1992). The program depicts a sphere representing a sea urchin (“uni” in Japanese), moving at a horizontal speed of 4 mm/s and following an irregular sine-wave locus. The sphere displays sudden increases in size at random intervals of 10 ± 3 s. Participants are instructed to target the sphere with the mouse cursor and click when the sphere increases in size. This work requires concentration to resist drowsiness (Araki *et al.*, 1992) and can be categorized as monotonous work. The software provides two indicators reflecting work performance: (1) tracking error (TE), indicating distance between the cursor and target as measured at 500-ms intervals and (2) RT, indicating the time taken to click when the target increases in size.

Data processing and statistical analysis

Distributions of TE and RT for each participant during Session 1 before exposure to aroma were examined (Figures 1 and 2). Values below the 25th percentile for both TE and RT for each participant during Session 1 were defined as the “concentration value” (CV) for each participant. For RT, values ≤ 200 ms were considered to have resulted from continuously pressing the mouse button and were excluded. CVs for both TE and RT were counted at 10-min intervals (Intervals 1–6) using 25th percentile values for each session to provide the number of responses while concentrating (NRC) for TE (NRC-TE) and RT (NRC-RT). In each 10-min interval, each participant provided 1200 values for TE and 50 values for RT.

Using control group data, inter- and intrasession variations were first analyzed using two-way analysis of variance (ANOVA), with Fisher’s least significant difference (LSD) test as the *post hoc* test. For factors displaying interactions, five sessions of six intervals each were analyzed at each level (one-way ANOVA, Fisher’s LSD test).

Next, data for each session were used for comparisons between all three groups (two-way ANOVA, Fisher’s LSD test). Values of $P < 0.05$ were considered statistically significant.

Results were inscribed as follows: the six intervals within the session were abbreviated as In1–6, and Sessions 1–5 were abbreviated as S1–5. Furthermore, differences in NRC (< or >) for session and interval were considered significant for values of $P < 0.05$.

Results

Control group

With NRC-TE (Figure 3), no interaction between session and interval was detected ($F_{20,330} = 0.576$, $P = 0.928$), but

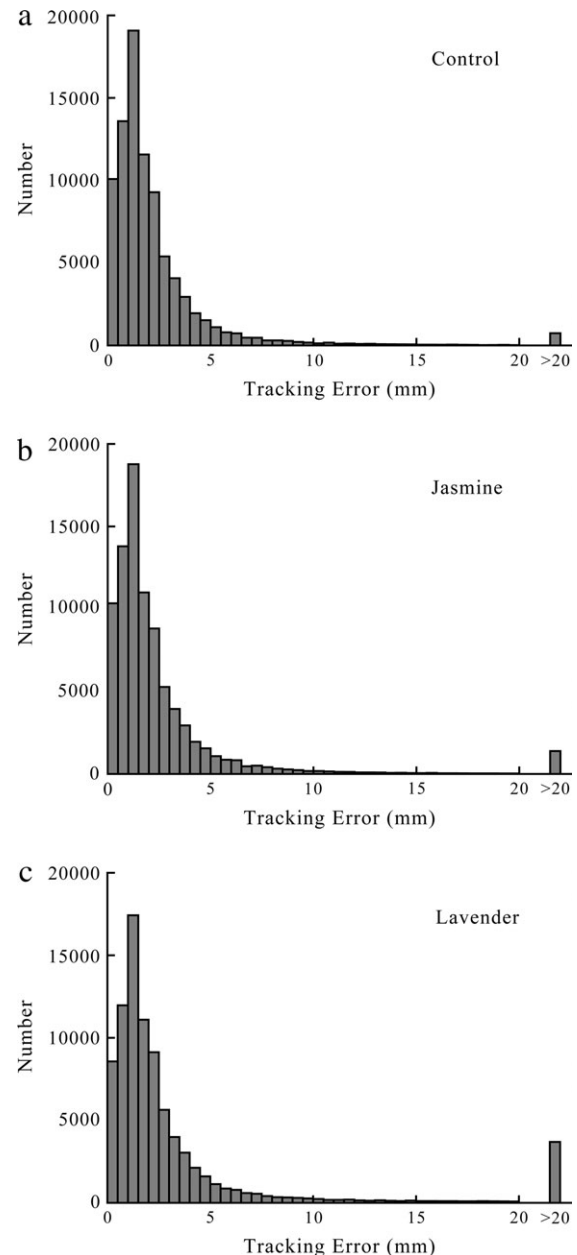


Figure 1 Histograms of TEs in S1 in each group.

effects were detected for both session ($F_{4,330} = 8.03$, $P < 0.001$) and interval ($F_{5,330} = 9.999$, $P < 0.001$). Comparison of sessions (Table 2) revealed that NRC-TE was highest in S5 (S5 > S2, S3, S4) and lowest in S4 (S4 < S1, S2, S5). Comparison of intervals showed that NRC-TE was highest at 0–10 min (In1 > In2, In3, In4, In5) and lowest at 30–40 min (In4 < In1, In2, In3) (Table 3).

With NRC-RT (Figure 4), effects for session ($F_{4,330} = 12.35$, $P < 0.001$) and interval ($F_{5,330} = 17.089$, $P < 0.001$) and interactions between them ($F_{20,330} = 1.867$, $P = 0.014$) were detected. Comparison of sessions revealed NRC-RT was highest in S1 (S1 > S2–S5) and lowest in S4 (S4 < S1,

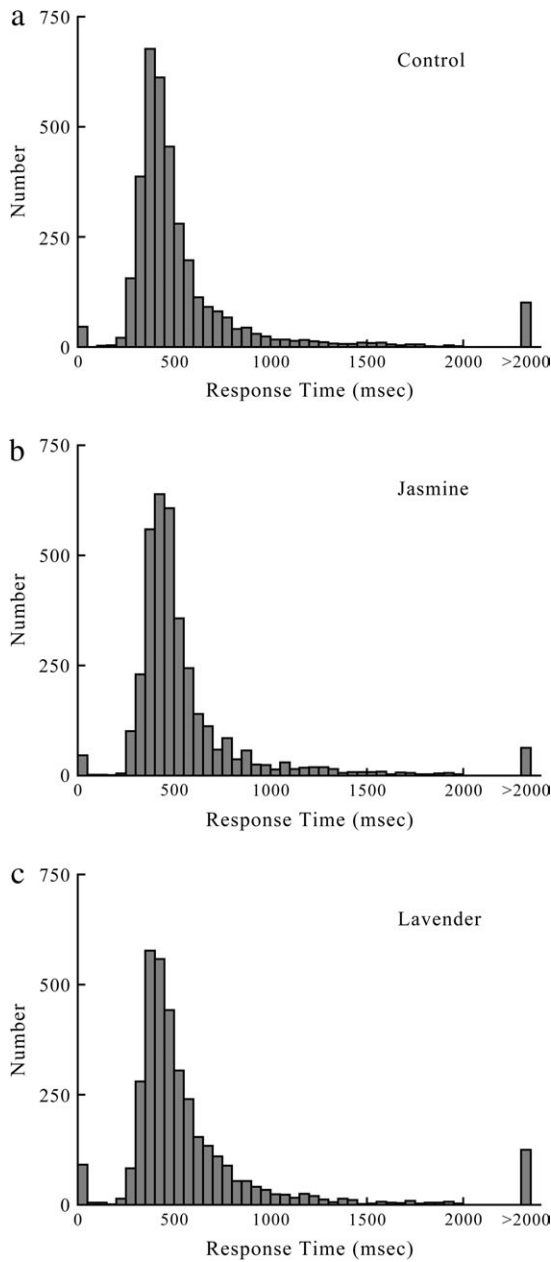


Figure 2 Histograms of RTs in S1 in each group.

S2, S5) (Table 2). Comparison of intervals showed that NRC-RT was highest at 0–10 min ($In1 > In2-5$) and lowest at 40–50 min ($In5 < In1-3$) (Table 3). An interaction between session and interval was detected, and high NRC-RT at In1 was apparent with regard to S1 and S3, particularly for S1.

Group comparisons by session

NRCs for the three groups in each session are described in Figures 5 and 6. No significant differences were noted between groups for S1, S2, S3, and S5 in terms of NRC-TE or NRC-RT. Significant differences were identified in S4 (Figure 5d, Figure 6d).

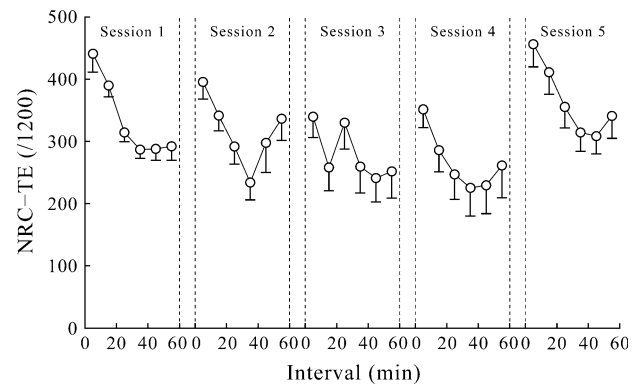


Figure 3 Number of responses while concentrating according to TE in the control group. Values represent mean \pm SEM.

Table 2 Comparison of mean NRC values between sessions in the control group

Session		NRC-TE difference	NRC-RT difference
S1	S2	19.181	3.306
	S3	55.264	4.583
	S4	66.625	5.417
	S5	-29.042	3.222
S2	S1	-19.181	-3.306
	S3	36.083	1.278
	S4	49.444	2.111
	S5	-48.222	-0.084
S3	S1	-55.264	-4.583
	S2	-36.083	-1.278
	S4	13.361	0.833
	S5	-84.306	-1.361
S4	S1	-68.625^a	-5.417^c
	S2	-49.444^b	-2.111^d
	S3	-13.361	-0.833
	S5	-97.667^c	-2.194^e
S5	S1	29.042	-3.222
	S2	48.222	0.083
	S3	84.306	1.361
	S4	97.667	2.194

Numbers represent differences between mean NRC values of two sessions. Lowest values for both TE and RT are in S4. ^a $P = 0.001$; ^b $P = 0.012$; ^c $P = 0.0001$; ^d $P = 0.011$; ^e $P = 0.009$.

NRC-TE displayed effects for group ($F_{2,198} = 3.991, P = 0.020$) and interval ($F_{5,198} = 7.427, P < 0.001$) but no interaction between group and interval ($F_{10,198} = 0.399, P = 0.946$). NRC-TE was significantly higher for the lavender

Table 3 Comparison of NRC in the control group in terms of interval

Interval		NRC-TE difference	NRC-RT difference
In1	In2	59.483	3.717
	In3	88.967	4.517
	In4	132.667	6.217
	In5	123.767	7.033
	In6	100.167	6.817
	In2	In1	-59.483
In3		29.483	0.8
In4		73.183	2.5
In5		64.283	3.317
In6		40.683	3.1
In3		In1	-88.967
	In2	-29.483	-0.8
	In4	43.7	1.7
	In5	34.8	2.517
	In6	11.2	2.3
	In4	In1	-132.667 ^a
In2		-73.183 ^b	2.5
In3		-43.7 ^c	1.7
In5		-8.9	0.817
In6		-32.5	0.6
In5		In1	-123.767
	In2	-64.283	-3.317 ^a
	In3	-34.8	-2.517 ^d
	In4	8.9	-0.817
	In6	-23.6	-0.217
	In6	In1	-100.167
In2		-40.683	-3.1
In3		-11.2	-2.3
In4		32.5	-0.6
In5		23.6	0.217

Numbers represent differences between mean NRC values for two intervals. ^a $P = 0.0001$; ^b $P = 0.001$; ^c $P = 0.043$; ^d $P = 0.006$.

group than for the jasmine or control groups ($P = 0.007$, $P = 0.044$, respectively). Comparison of intervals showed that NRC-TE was highest at In1 for all groups.

NRC-RT displayed effects for group ($F_{2,198} = 4,283$, $P = 0.015$) and interval ($F_{5,198} = 5,505$, $P < 0.001$) but no interaction between them ($F_{10,198} = 0.471$, $P = 0.907$). NRC-RT for the lavender group was significantly higher than NRC-RT for the control group ($P = 0.005$) and tended to be higher

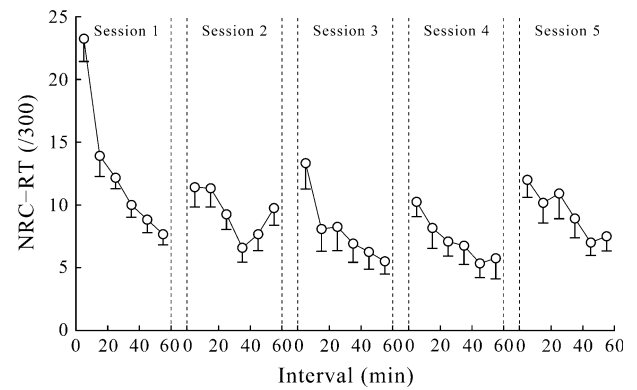


Figure 4 Number of responses while concentrating according to RT in the control group. Values represent mean \pm SEM.

than NRC-RT for the jasmine group ($P = 0.051$). Comparison of intervals indicated that NRC-RT was highest at In1 for all groups.

Discussion

Some interesting observations were gained from this research. First, as an indicator of concentration, NRCs within each session tended to display a U-shaped curve (Figures 5 and 6). This pattern was also noted between sessions for intergroup comparisons (Figures 5 and 6). With the Uchida-Kraepelin test, mean work performance traces a U-shaped curve, gradually declining from start to 60–70% then climbing in what is called “The Last Spurt Effect” (Kuraishi *et al.*, 1957). A similar curve was obtained for the work using UNI, indicating that UNI is a simple task similar to the Kraepelin test, which is largely uninfluenced by learning and/or technical experience (Kuraishi *et al.*, 1957).

The second point was the variation between sessions seen in the control group (Figures 3 and 4). NRC in S4 (1430–1530) was low (S4 < S1, S2, S5), and this time coincides with the time in which work efficiency is known to decrease due to circadian rhythm (Broughton, 1989; Monk *et al.*, 1996). This time of day also matches the period in which most traffic accidents are recorded (Mitler *et al.*, 1988; Pack *et al.*, 1995). A report by Hagiwara *et al.* (1997) utilizing the same UNI performance test found that reduced TE and RT performance was correlated with decreased arousal on EEG, using α -wave attenuation as the indicator. Levels of drowsiness and fatigue are known to display an inverted U-shaped curve during work performance (Yerkes and Dodson, 1908; Wrisberg, 1994). The decrease in concentration observed in S4 in the control group indicates that S4 was at the bottom of the U-shaped curve in NRC of all sessions. This session was thus considered the session most affected by low levels of arousal and high fatigue.

The third point of note in the present study was the effect of exposure to aroma during recesses, the main subject of this experiment. Concentration levels in the three groups started

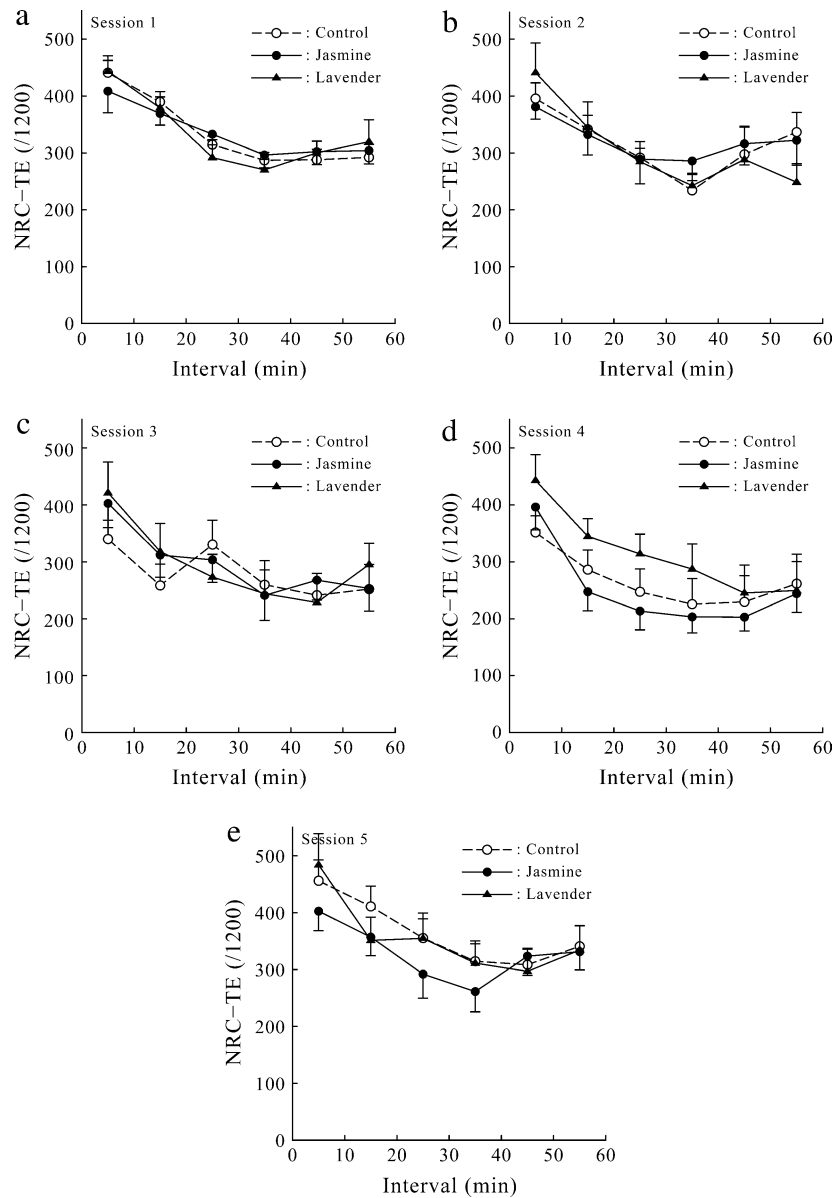


Figure 5 Number of responses while concentrating according to TE in S1-5. Values represent mean \pm SEM.

as equivalent in S1 but separated as sessions and recesses proceeded to the point where significant intergroup differences were identified in S4 (Figures 5 and 6). In S4, where concentration in the control group was decreased, both NRC-TE and NRC-RT were significantly increased in the lavender group compared to the control group (Figures 5d and 6d). Conversely, NRC-TE was significantly lower in the jasmine group than in the lavender group in S4 (Figure 5d).

These three points can be summarized as follows. The present experiment reflected performance efficiency in the case of simple work performance. At the time when performance was minimal in the control group, factors such as fatigue, drowsiness, and circadian rhythm may be relevant. However, at this specific time in the afternoon, a period of rest

from work with exposure to lavender aroma appears to have been effective in sustaining efficiency in the next work session, whereas exposure to jasmine aroma was ineffective.

As stated above, exposure to lavender aroma has been considered by some studies to negatively influence working efficiency. The present findings indicate that lavender aroma may also exert positive effects on working efficiency in some situations. As Degel and Koster (1999) indicated using the Yerkes-Dodson law (Yerkes and Dodson, 1908; Wrisberg, 1994), an optimal stimulation range is present for work performance, and if that range is surpassed, performance efficiency may decrease. In this study, participants were assigned five 60-min tasks, and strict attention was required during each task. An effective break during each recess may

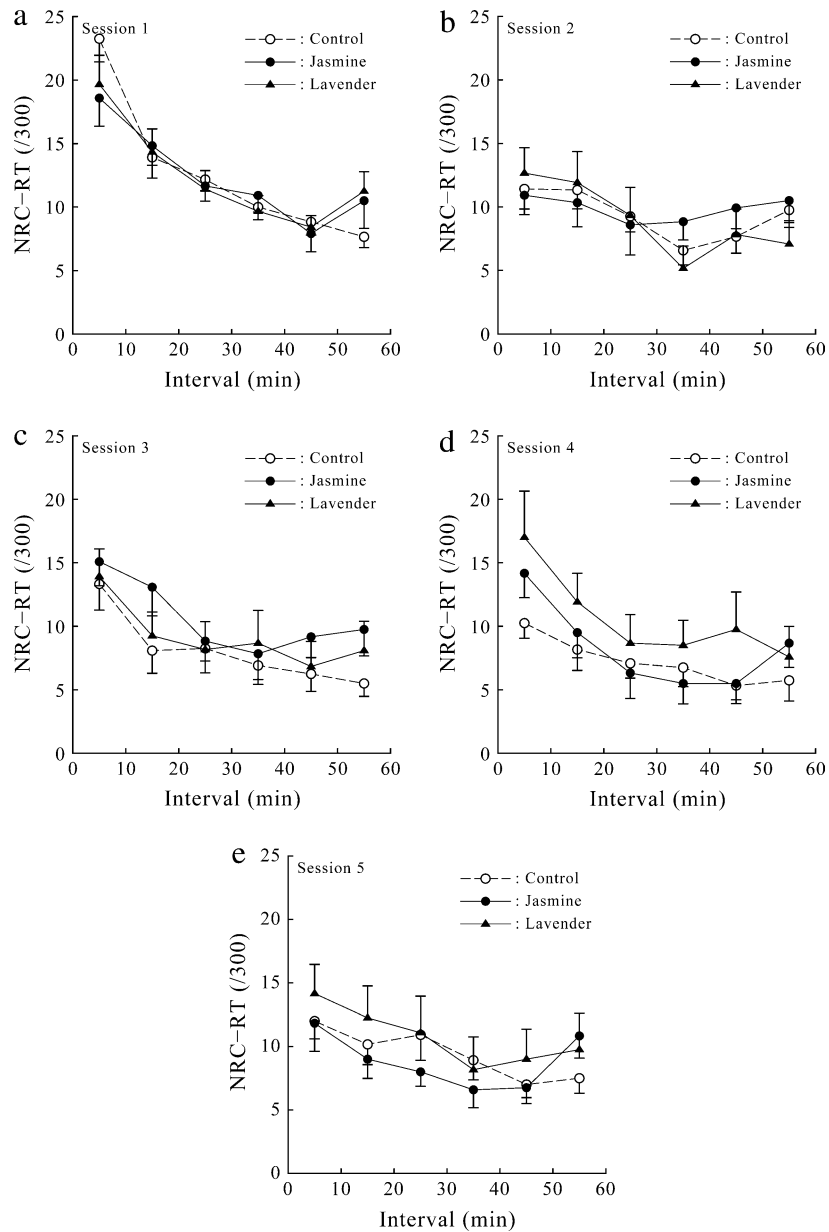


Figure 6 Number of responses while concentrating according to RT in S1-5. Values represent mean \pm SEM.

thus be considered important in maintaining optimal arousal level. Arousal in recesses in the afternoon when fatigue accumulated after completion of a few tasks may have become excessive, leading to negative effects on the next task. Jasmine aroma is considered to possess stimulatory effects and, thus when applied before S4, may have acted to decrease work efficiency in the session. Conversely, lavender aroma may have decreased arousal during the recess to achieve more optimal levels for the next task. This effect of lavender aroma was assumed to become significant in the time period when fatigue and drowsiness tend to accumulate, so participants exposed to lavender aroma during

recesses could retain higher working efficiency than those with jasmine or controls.

Analysis of the kinetic momentum of mice suggested the sedative effects of lavender aroma (Buchbauer *et al.*, 1991), while the arousing effects of jasmine aroma on mice sedated using pentobarbital has been reported (Tsuchiya *et al.*, 1991). Various other properties have been described for lavender aroma. These include autonomic effects, such as reductions in electrodermal activity and electric skin resistance, increases in skin blood volume, and reductions in heart rate (Vernet-Maury *et al.*, 1999). A “sense of euphoria” is reportedly easily attained on exposure to lavender aroma

(Besedovsky et al., 1979; Vernet-Maury et al., 1999), anxiety, tension, and depression are reduced (Lorig and Schwartz, 1987; Diego et al., 1998), and feelings of stress are lowered (Motomura et al., 2001). Such reports suggest that lavender aroma lowers arousal levels, suppresses sympathetic stimulation, and acts to improve mood and decrease stress. The features of lavender aroma described above were considered significant in this study, allowing participants to take an effective break before the next task.

The present research did display a number of limitations. A crossover design was not utilized, and participants with a comparable concentration level may have tended to gather in specific groups. The study measured work performance using NRC for the two indicators determined by UNI software. However, since other related indicators (e.g., other types of work performance indicator, EEG or electrodermatography) were not measured, overall interpretations cannot be made. Furthermore, the research was conducted within the space of 1 day, so whether the same results would be achieved over a longer period of time remains to be clarified. Investigation of how preferences for the aromas of lavender or jasmine may influence the results in this kind of experiment would also be useful using groups including participants with significantly higher or lower preferences for specific aromas.

Physiological examination using methods such as EEG may prove useful, given the need to clarify the mechanisms of action for lavender aroma in this time period, including alterations in arousal level and the autonomic nervous system.

In summary, work performance during the course of a typical business day (0930–1700) appears to reach the lowest point around 1430–1530. Lavender aroma provided in a recess period prior to this time appears to improve concentration in contrast to the use of jasmine or the absence of aroma. Although lavender is typically considered a sedative-type aroma, the results of this study indicate the possibility that the described effects of lavender used during recesses are effective for maintaining work efficiency for a certain time period. The effects of lavender aroma presented during recess before work have largely gone unreported. Further investigation is required to evaluate the effects of lavender aroma during recesses in terms of changes in arousal level and autonomic nervous system responses using EEG and physiological tests.

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