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EFFECTS OF ODORS ON CARDIAC RESPONSE PATTERNS AND SUBJECTIVE STATES IN A REACTION TIME TASK

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The effect of odors on cardiac response patterns were investigated during the foreperiod of a two-stimulus paradigm in a simple reaction time task. Heart rate deceleration (DE) usually seen just prior to imperative stimulus is thought to reflect the process of anticipation or attention. Odors (e.g.lemon) credited with having stimulant effect are expected to activate this process, while odors with sedative effect are thought to exert a suppressive effect. Eight female university students served as subjects in the first experiment that was designed to clarify the relation between these effects and concentration of odors by the DE amplitude. In the second experiment, ten career female served as subjects and after each trial subjective states were measured by a questionnaire. Olfactory stimulus was provided to subjects by the blast method. The results indicated that: 1)the odor of lemon had the effect of activating anticipation or attention process, this effect tended to be stronger by increasing odor concentration, 2)the rose odor had the effect of suppressing this prosess, this effect was observed across all concentration levels, 4)the effect of odors tended to be stronger when a subject felt the odor was preferable.

Key words: heart rate(HR), cardiac deceleration, reaction time, foreperiod, questionnaire, odor, perfume

INTRODUCTION

Fragrance materials such as perfumes have long been known to exert effects on the mind and body. Throughout history, fragrances have been credited with having sedative and stimulant effects. The lemon fragrance is usually regarded as a stimulant, while the smell of rose is regarded as a sedative. This experiment concerned the effect of these two fragrances on the psychophysiological process related to anticipation or attention in a reaction time task.

In this study, the effect of odors on cardiac response patterns was investigated during the foreperiod of a two-stimulus paradigm in a simple reaction time task. Changes in the cardiac response pattern were typically triphasic (deceleration D1; acceleration A1; deceleration D2) between the warning stimulus (WS) and imperative stimulus (IS) (e.g.,

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Bohling & Kjellberg, 1979). There was sometimes a significant negative correlation between heart rate deceleration (D2) usually seen just prior to IS and reaction time in this key pressing task (e.g., Hatayama, Yamaguchi, & Ohyama, 1981). Heart rate deceleration (D2) is thought to reflect the process of anticipation or attention (e.g., Chase, Graham & Graham, 1968; Damen & Brunia, 1987). The present study explored the effect of odors on heart rate deceleration (D2) in this reaction time task and the processes of anticipation, attention and motor preparation. And stimulative odors (lemon) are expected to activate those processes while sedative odors (rose) are thought to exert a suppressive effect.

METHOD

EXPERIMENT 1

Subjects: Eight female university students ranging in age from 20 to 24 served as subjects.

Apparatus: The olfactory stimuli consisted of 7 different aromatic air samples and one odorless air control(table 1). First, 1%, 0.1% and 0.01% concentrations of lemon were prepared and these were used as standard concentrations. Next, rose and floral concentrations that had an equivalent sensory intensity to each lemon concentration, were prepared by the perfumer. Concentrations were made on a weight basis by diluting the fragrance with triethyl citrate. Dry air was bubbled through each odor solution and the aromatic air sample was presented to the subject by the blast method through a teflon tube to the entrance of one nostril. The presentation of the olfactory stimuli was controlled by an olfactometer made by Oumi Odor Air Service.

Table 1. Concentrations of odorant solusions (Experiment 1)

perfume	conc.1	conc.2	conc.3
Lemon	1.00%	0.10%	0.01%
Rose	6.00%	0.40%	0.03%
Floral	6.00%	—	—

Procedure: The experiment consisted of two different session with a 5-minute rest period between sessions. Each session consisted of 24 trials. The 8 different olfactory stimuli were randomly presented 3 times a session. A single trial consisted of a 5-second rest period, followed by a 20-second fragrance period in which the olfactory stimulus was presented. This was followed by a 10-second foreperiod lasting from the WS tone to the IS tone, then by a 15-second post period after the onset of the IS tone.

Subjects were instructed to press the response key as quickly as possible after the onset of the IS tone. The WS was a 3.5KHz 62dB tone lasting one second. The IS was a 2.5KHz 81dB tone lasting until the subject pressed the response key. One trial protcol and typical components of HR changes were exhibited in the figure 1.

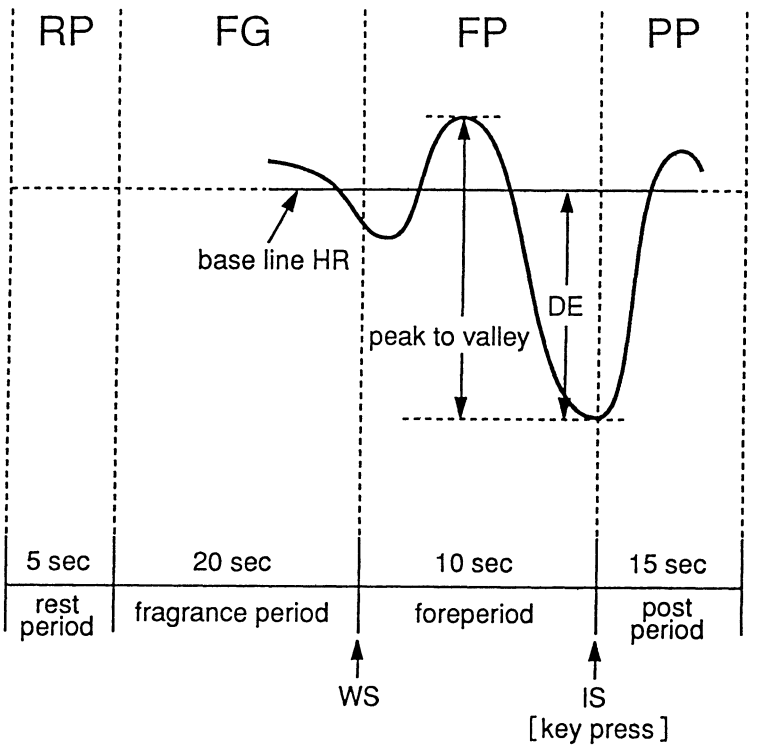

Fig. 1. Trial protocol and HR components.
(WS: warning stimulus; IS: imperative stimulus)

EXPERIMENT 2

Subjects: Ten career females ranging in age from 24 to 29 served as subjects.

Apparatus: The olfactory stimuli consisted of lemon 1%, rose 6% and 3 other fragrances formulated by the perfumer. Apparatus was the same as in experiment 1.

Procedure: The experimental conditions were essentially the same as in experiment 1, except that the subjective states were measured by a questionnaire in a 25-second period following the post period in each trial. The experiment consisted of three 18-trial sessions with a 5-minute rest period between sessions.

The questionnaire consisted of 5 questions. Subjects were asked to rate their preference for an odor and to indicate the extent to which the odor made them feel refreshed or relaxed. They were also asked to estimate how quickly they had pressed the key. Responses to these 4 questions were scored on 100mm visual analog scales. In the fifth question, they were asked how they thought the odor effected their reaction time. This question asked subjects to choose between "good effect", "bad effect" and "no effect". It was assigned that a value of +1 to the response "good effect", -1 to "bad effect" and 0 to "no effect". The data in each trial was

handled by dividing responses from subjects into two categories. Responses in a trial in which subject's preference for an odor was higher than 50 points on the analog scale were compared with responses in a trial less than 50 points.

In this study the difference between lemon and rose with regard to heart rate deceleration, subjective feelings of refreshment or relaxation, and subjective feeling about performance on the reaction time task were examined. And the relationship between odor preference, amplitude of HR deceleration and subjective rating of the odor as refreshed or relaxed was studied.

Heart rate data were analyzed using a Nihon Kouden ATAC-3700 wave analyzer and an NEC PC-9801 personal computer.

Results and Discussion

EXPERIMENT 1

In this report, only trials for lemon, rose and odorless air control are discussed.

The baseline heart rates were calculated as the average heart rate for each trial in the 5-second rest period before the fragrance period. No significant differences were observed in the baseline heart rates between the odorants and control.

Changes in heart rate show differences from the baseline heart rate. Changes in HR during the foreperiod under the highest concentration condition of olfactory stimulation (lemon 1% and rose 6%) are shown in Figure 2. The deceleration (peak to valley) amplitude showed a lemon>control>rose relation in the highest concentration condition. This effect was statistically significant in session 2 ($F(2/56)=6.627$; $p<0.01$). Ratios were calculated for the amplitude of heart rate deceleration by comparing the change in HR in each lemon and rose condition to the change in HR in the odorless control condition (Figure 3). The difference between lemon and rose was greatest at the highest concentration and successively less at the lower concentrations.

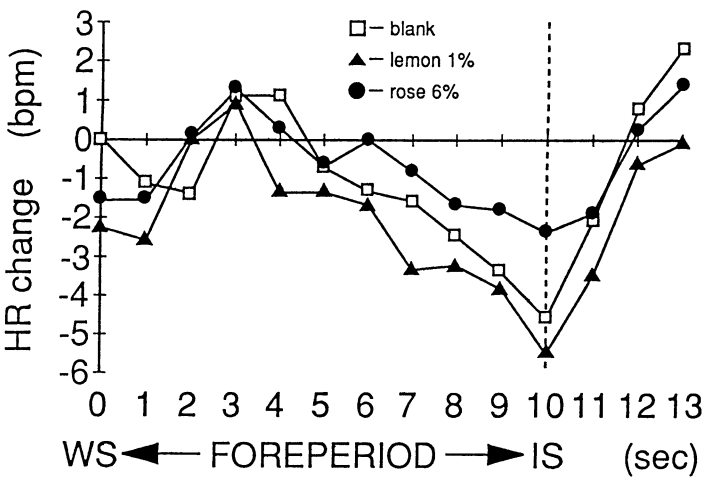

Fig. 2. Change in HR under highest olfactory stimulus intensity condition.

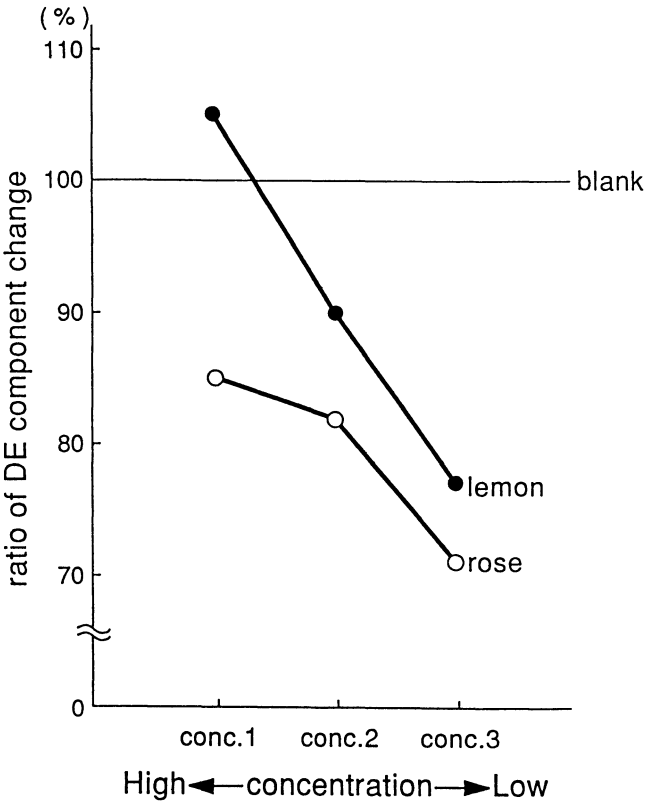

Fig. 3. Change in HR deceleration across odor concentration.

No significant differences were observed in reaction time scores between the odorants and control.

EXPERIMENT 2

The change in HR deceleration for lemon was larger than for rose. There was no difference in HR change between lemon and the control. The differences in heart rate deceleration between lemon and rose tended to be more pronounced when the subjects' preference for an odor was higher than 50 points (Figure 4).

There was a moderate tendency for subjects, when they preferred an odor, to rate the odor of lemon as "refreshed" and to rate rose as "relaxed" (Figure 5). Figure 6 shows how the subjects rated the effect of an odor on their performance in the reaction time task. Subjects tended to rate the effect of lemon as good. This tendency was stronger when subjects preferred this odor. And figure 7 shows the subjective rating of reaction time versus odor preference. This rating expressed the subject's evaluation of how well she had performed on each trial. There was a moderate tendency for subjects who preferred the smell of lemon to rate their feelings about performance higher. When they didn't prefer an odor, this feeling was stronger in rose than in lemon.

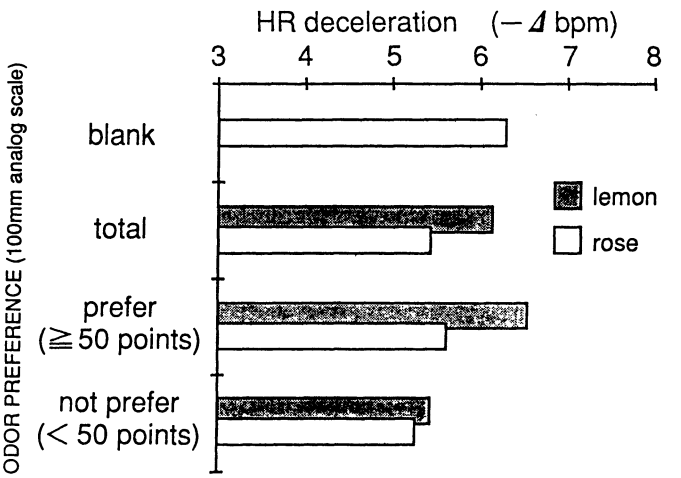

Fig. 4. HR deceleration (DE) in two groups classified by response to odor preference questionnaire.

These results are thought to suggest that the odor of lemon is stimulant and the rose odor is sedative. The differences in heart rate deceleration in the foreperiod between lemon and rose tended to be more pronounced when the subjects preferred an odor. And there was no difference when the subjects did not prefer an odor. These could be interpreted from the intake-rejection hypothesis (e.g., Lacey 1967). The odor of lemon, thought to be stimulant, had the effect of activating anticipation or attention process, as evidenced by an increase in HR deceleration being associated with 'sensory intake'. Especially when a subject felt an odor preferable, that is, when subject was supposed to take psychophysiological set to 'intake' the preferable odor, the activating effect of lemon was prominent. On the other hand, the rose odor, thought to be sedative, had the effect of suppressing this process, as evidenced by small deceleration. When subject didn't prefer an odor, that is, in the case of 'rejection' of sensory stimulus, the effect of the odor on HR deceleration was small whether the odor was lemon or rose. This interpretation will be comfirmed only by future investigation. But at least there is the relation between the effect of odor and odor preferance, and the effect of odor tended to be stronger when a subject felt the odor preferable.

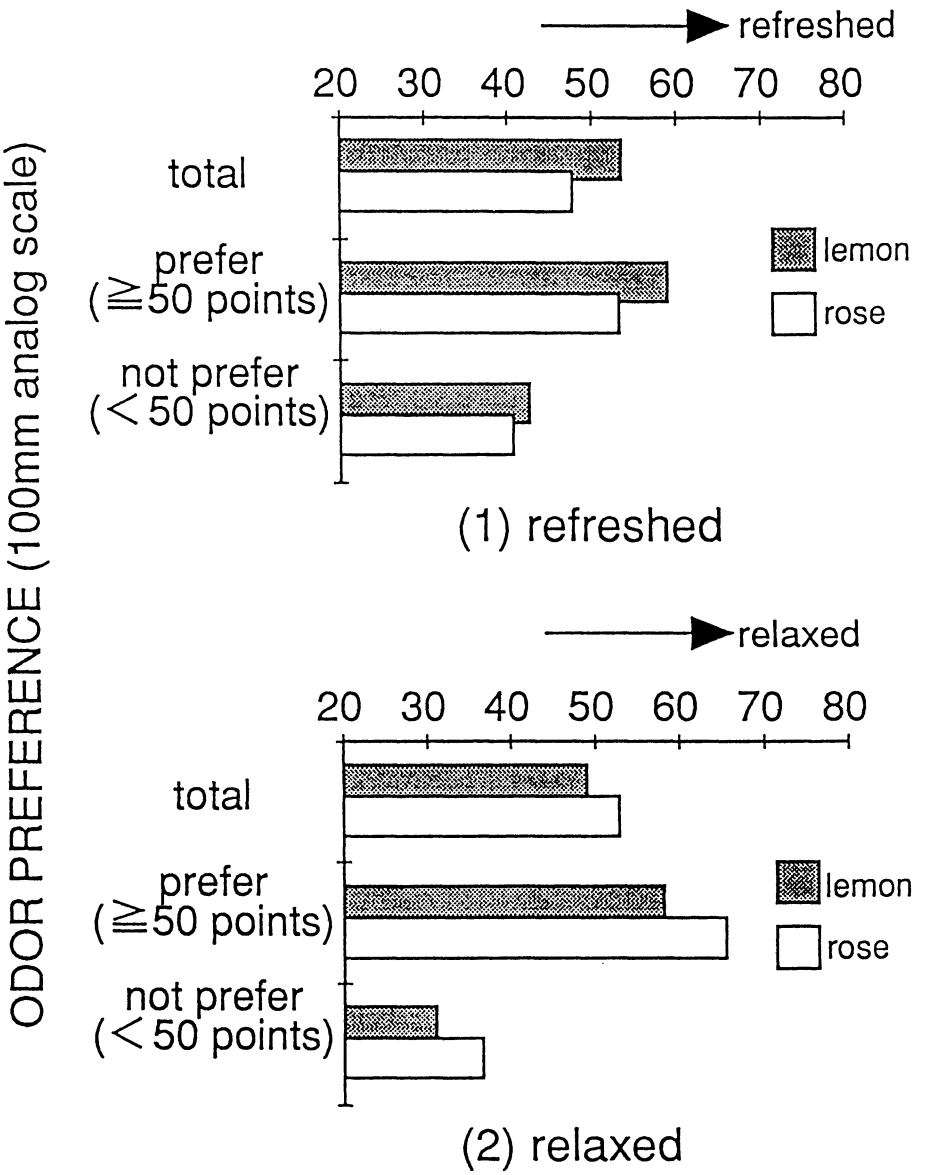

Fig. 5. Subjective feeling of "refreshed" or "relaxed" versus preference for odor.

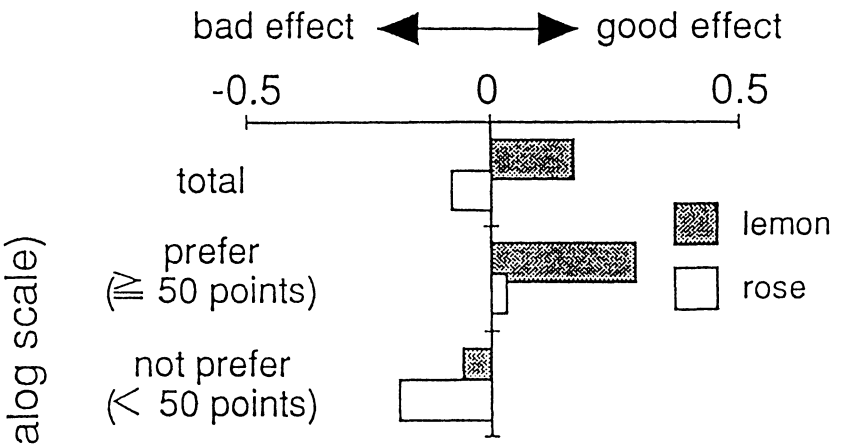

Fig. 6. Subjective feeling of the effect of odor on key press versus odor preference.

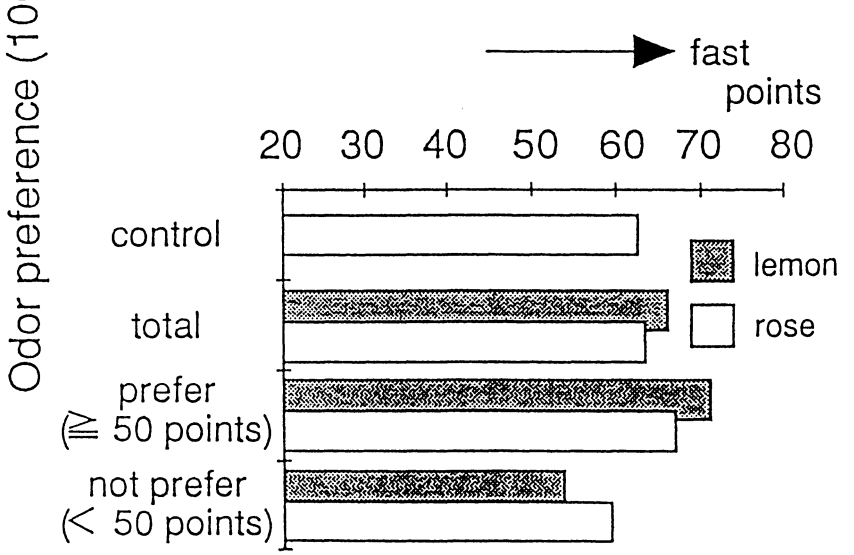

Fig. 7. Subjective feeling of response versus odor preference.

Conclusions

The odor of lemon 1% had the effect of activating the process of anticipation or attention, as shown by the increased amplitude of HR deceleration just before imperative stimulus in the foreperiod. This effect tended to decrease with decreasing odor concentration. On the other hand, the rose odor had the opposite effect of suppressing this process, and this effect was observed across all odor concentration levels. And the effect of odors tended to be stronger when a subject felt the odor was preferable.

Lemon was almost felt to be refreshing, and rose to be relaxing. Subjects tended to feel that lemon had a good effect on their performance in the reaction time task. The subjective effect of odors also tended to be stronger when a subject felt the odor was preferable.

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