Autonomic Nervous Responses According to Preference for the Odor of Jasmine Tea

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The effect of jasmine tea odor on the autonomic nervous system was investigated by a power spectral analysis of the heart rate variability. We assigned eight volunteers to two groups with either a predilection for or antipathy toward the jasmine tea odor. We tested both high- and low-intensity jasmine tea odors. The low-intensity odor was produced by diluting 20-fold the jasmine tea used for the high-intensity odor test. The low-intensity odor produced an increase in parasympathetic nervous activity in both the predilection and antipathy groups. The high-intensity odor produced an increase in parasympathetic nervous activity in the predilection group, but an increase in sympathetic nervous activity in the antipathy group. The odor of Chinese green tea, a basic ingredient of jasmine tea, produced no effects similar to those of the jasmine tea odor. These results suggest that the jasmine tea odor activated the parasympathetic nerve, whereas the higher-intensity odor activated the sympathetic nerve in those subjects who disliked the odor.

Key words: jasmine tea; odor; autonomic nervous system; power spectral analysis; preference

Materials and Methods

Subjects. Data were collected from healthy normotensive Japanese volunteers (five men and three women) ranging in age from 21 to 36 years (25.4 years mean age) who were non-smokers. The mean body mass index was 20.90 kg/m². After each subject had been briefed on the object and method of our experiment, informed consent was obtained from them according to the guidelines established by the declaration of Helsinki.

Power spectral analysis. To evaluate the autonomic nervous activity, we used a power spectral analysis of the temporal intervals between each heart beat.
Fig. 1. Typical Pattern of Change in the R-R Interval (upper panel) and Corresponding Spectral Curve (lower panel).

The white area is the high-frequency component (HFC), and the black area is the low-frequency component (LFC). HFC is associated almost entirely with the vagal nerve activity, and LFC might be mediated by both the vagal and sympathetic nerve activity.

(R-R intervals). Details of the power spectral analysis procedure have been fully described elsewhere. Briefly, electrocardiographic (ECG) signals were recorded from electrodes placed in the CM5 position. The signal was digitized on-line by a 13-bit analog-to-digital converter (PS-2032GP, TEAC, Japan) at a sampling rate of 1,000 Hz. The digitized ECG signal was differentiated, and the resulting QRS spikes and intervals between the impulses (R-R intervals) were stored sequentially on a hard disk for later analysis. After passing through a Hamming-type data window, a power spectral analysis by a fast Fourier transformation was then performed on consecutive 256-s time series of the R-R interval data obtained during the test.

To evaluate the autonomic nervous system activity of each subject in the present study, we analyzed the low-frequency component (LFC, 0.035–0.15 Hz) and the high-frequency component (HFC, 0.15–0.5 Hz), this latter being the respiration-linked component (Fig. 1). In general, HFC is associated almost entirely with vagal nerve activity, while LFC might be mediated by both vagal and sympathetic nerve activity.

Since the basal autonomic nervous activity and heart rate differ among individuals, the mean value for the heart rate before inhalation was set as the baseline, and the mean value for autonomic nervous activity before inhalation was standardized to 100%, the relative values after the inhalation of odors then being compared.

All subjects breathed in synchrony with a metronome at 15 times·min⁻¹ (0.25 Hz) to ensure that respiratory-linked variations in heart rate did not overlap with low-frequency heart rate fluctuations (below 0.15 Hz) from other sources.

Profile of mood states (POMS). The POMS test has been successfully used to examine mood changes. We administered a POMS test, which had been translated into Japanese, just before and after the measurement of R-R intervals. The POMS test comprised 65 questions about the current mood state. These 65 questions contain 7 dummies and 58 other questions classified into 6 sub-scales: T-A (tension and anxiety), D (depression and dejection), A-H (anger and hostility), V (vigor), F (fatigue), and C (confusion). The subjects selected the raw score from one of five values (0, 1, 2, 3 and 4, where 0 = no such mood state and 4 = extreme mood state). These raw scores in each sub-scale were then added to generate each sub-scale score.

Materials. We used high- and low-intensity jasmine tea odors and Chinese green tea odors. Jasmine tea produced in Fujian province of China in September 1999 was used. It was prepared from pan-fixed and basket-dried Chinese green tea (Camellia sinensis L.) scented with flowers of Jasminum sambac. After the scenting process, the flowers were removed from the tea, and dried flowers of J. sambac were newly added to about 1% of the weight of the tea. The high-intensity odors of jasmine and green tea were produced by adding 25 g of jasmine tea leaves (or green tea leaves) to 1 l freshly boiled water and steeping them for 1 min. This is the standard method by which tea is usually prepared. The low-intensity odors were produced by diluting the jasmine or green tea 20-fold. The odor of the 20-fold diluted jasmine tea was judged weaker than that of the original jasmine tea by all subjects and was near the threshold level for detection. Water was used as the control.

The odor was produced by bubbling air through jasmine or green tea in an air-tight bottle with an air pump (1.5 l/min), and was directed to the nose through a stainless steel tube. A nuche was attached to the outlet of the tube to reduce any wind stress produced by the outlet pressure. The odor was presented continuously for 5 min.
Protocol. Measurements were carried out for three months and taken in a quiet room at 50% humidity and at a temperature which the subjects judged comfortable. The subjects were required to have breakfasted before 09.00 h on the days of the experiment, and to abstain from food, drink, and exercise until the experiment had been completed. To avoid the influence of circadian rhythm, each measurement began between 10.45 and 11.00 h.

The subjects were instructed to initially rest for more than 10 min in the sitting position with the ECG electrodes attached. Before the ECGs were recorded, the subjects took the POMS test. The ECG was recorded for 18 min before inhalation, for 5 min during inhalation, and for 54 min after inhalation. The subjects then took the POMS test again.

All subjects inhaled each odor of jasmine tea, green tea and water on different days. Immediately after the inhalation of an odor, each subject stated the preference for that odor (i.e., predilection or antipathy). The subjects were then classified according to their preference for each odor, in five groups: 1) subjects with a predilection for the jasmine tea odor; 2) those with antipathy for the jasmine tea odor; 3) those with a predilection for the green tea odor; 4) those with antipathy for the green tea odor; and 5) control subjects who inhaled the water odor. Each subject inhaled each odor one or two times. The preferences of some subjects who inhaled the jasmine tea odor two times were different. Consequently, they belonged to both groups 1 and 2 because they rated the odor as pleasant on one occasion, but unpleasant on the other. The respective number of such subjects was two and three when inhaling the high-intensity and low-intensity jasmine tea odor. Similarly, when some subjects inhaled the green tea odor, they could be categorized into both groups 3 and 4. The respective number of such subjects was two and one when inhaling the high-intensity and low-intensity green tea odor. All subjects were tested for their response to inhalation of the water odor.

Statistical analyse. Each data value is expressed as the mean ± standard error of the mean (SE). The effects of time, treatment, and time × treatment were evaluated by two-way repeated-measures ANOVA and by a contrast test. To compare each group at certain times, one-way ANOVA was used. Statistics were calculated with the StatView software package (Macintosh version J 5.0, Abacus Concepts, Berkeley, CA, USA) and the Super ANOVA software package (Macintosh version 1.11, Abacus Concepts). A probability level of <0.05 is considered significant.

Results

Change in the autonomic nervous system after inhaling the high-intensity odors

Figures 2, 3 and 4 respectively show the time-course characteristics for the heart rate, HFC (which reflects parasympathetic nervous activity), and LFC (which reflects sympathetic nervous activity) before and after inhaling the high-intensity odors. The heart rate decreased with time in those subjects with a predilection for the jasmine tea odor and in the subjects with a predilection for the green tea odor (P<0.01). When the subjects inhaled the water odor, the heart rate also decreased with time (P<0.05), although this decrease probably resulted from sitting quietly. However, no significant interaction was apparent between the five groups. The heart rate of those subjects with a predilection for the jasmine tea odor was significantly lower at 21 min than the heart rate of the subjects inhaling the water odor. The heart rate also tended to be lower in those subjects with a predilection for green tea than in those subjects inhaling the water odor.

HFC increased with time in the subjects with a predilection for either the jasmine or green tea odor (P<0.01). However, no significant interaction was apparent among the five groups. HFC in those subjects with a predilection for the jasmine tea odor began to increase 15 min after inhalation, and was
Fig. 3. Time-course Characteristics for the Change to HFC, Reflecting Parasympathetic Nervous Activity, before and after Inhaling the High-intensity Jasmine and Green Tea Odors.

The subjects inhaled an odor for 5 min from 0 time. The mean values of parasympathetic nervous activity before inhalation are standardized to 100%, and all are expressed as relative values. Each value is given as the mean ± S.E.M. (n = 4–8). *JT (pleasant) = 6, GT (pleasant) = 6, JT (unpleasant) = 4, GT (unpleasant) = 4, water = 8. A significant difference was apparent between each group (P < 0.05; * JT (pleasant) group vs. JT (unpleasant) and the water group by ANOVA and the post hoc Tukey test).

Fig. 4. Time-course Characteristics for the Change in LFC, Reflecting Sympathetic Nervous Activity, before and after Inhaling the High-intensity Jasmine and Green Tea Odors.

The subjects inhaled an odor for 5 min from 0 time. The mean values for parasympathetic nervous activity before inhalation are standardized to 100%, and all are expressed as relative values. Each value is given as the mean ± S.E.M. (n = 4–8). *JT (pleasant) = 6, GT (pleasant) = 6, JT (unpleasant) = 4, GT (unpleasant) = 4, water = 8. A significant difference was apparent between each group (P < 0.05; * JT (pleasant) group vs. JT (unpleasant) and the water group by ANOVA and the post hoc Tukey test).

significantly higher after 21 min than in the subjects with antipathy for the jasmine tea odor and in the subjects inhaling the water odor. At 15 min after inhalation, HFC tended to be higher in the subjects with a predilection for either the jasmine tea odor or green tea odor than in the other subjects.

LFC increased with time in the subjects with either a predilection for the jasmine tea odor or antipathy for both the jasmine and green tea odors, and in the subjects inhaling the water odor (P < 0.01). However, no significant interaction was apparent among the five groups. LFC at 21 min was significantly higher in those subjects with antipathy for the jasmine tea odor than in those inhaling water odor.

**Difference in POMS test scores before and after inhaling a high-intensity odor**

Figure 5 shows the difference in scores between pre-inhalation and post-inhalation for the six sub-scales of the POMS test when the subjects inhaled the high-intensity odors. Most scores, especially that for depression (D), tended to decrease after inhalation of the jasmine tea odor by those subjects with a predilection for this odor. This suggests that these subjects became calm or relaxed after inhalation. In contrast, most scores, especially the score for anger and hostility (A-H), tended to increase after inhalation of the jasmine tea odor by those subjects with antipathy for the jasmine tea odor, suggesting that they became excited or irritated.

When the subjects inhaled the green tea odor, the change in T-A score differed between those subjects with a predilection for the green tea odor and those with antipathy for this odor. These scores tended to decrease in the subjects with a predilection and to increase in the subjects with antipathy.

**Change in the autonomic nervous system due to inhaling a low-intensity odor**

Figures 6, 7 and 8 show the time-course characteristics for the heart rate, HFC, and LFC before and after the inhalation of the low-intensity odors. The heart rate decreased with time in those subjects with a
Fig. 6. Time-course Characteristics for the Heart Rate before and after Inhaling the Low-intensity Jasmine and Green Tea Odors.

The subjects inhaled the odor for 5 min from 0 time. Mean values before inhalation were set as the baseline values, and each value is expressed as the mean ± S.E.M. (n = 4–8). n per group: JT (pleasant) = 7, GT (pleasant) = 4, JT (unpleasant) = 4, GT (unpleasant) = 5, water = 8. The decrease was significantly greater in the JT (pleasant) group than in the water, GT (pleasant), and GT (unpleasant) groups, and greater in the JT (unpleasant) group than in the water and GT (unpleasant) groups (time × treatment effect, P < 0.01, by repeated-measures ANOVA and a contrast test). A significant difference was apparent between each group (JT (pleasant) group vs. water group by ANOVA and the post hoc Tukey test).

Fig. 7. Time-course Characteristics for the Change in HFC, Reflecting Parasympathetic Nervous Activity, before and after Inhaling the Low-intensity Jasmine and Green Tea Odors.

The subjects inhaled the odor for 5 min from 0 time. Mean values of parasympathetic nervous activity before inhalation are standardized to 100, and all are expressed as relative values. Each value represents the mean ± S.E.M. (n = 4–8). n per group: JT (pleasant) = 7, GT (pleasant) = 4, JT (unpleasant) = 4, GT (unpleasant) = 5, water = 8. The increase was significantly greater in the JT (pleasant) group than in the water, GT (pleasant), and GT (unpleasant) groups (time × treatment effect, P < 0.01, by repeated-measures ANOVA and a contrast test). A significant difference was apparent between each group (JT (pleasant) group vs. water group by ANOVA and the post hoc Tukey test).

Fig. 8. Time-course Characteristics for the Change in LFC, Reflecting Sympathetic Nervous Activity, before and after Inhaling the Low-intensity Jasmine and Green Tea Odors.

The subjects inhaled the odor for 5 min from 0 time. Mean values for parasympathetic nervous activity before inhalation are standardized to 100%, and all are expressed as relative values. Each value represents the mean ± S.E.M. (n = 4–8). n per group: JT (pleasant) = 7, GT (pleasant) = 4, JT (unpleasant) = 4, GT (unpleasant) = 5, water = 8.

HFC increased with time in those subjects with a predilection for the jasmine tea odor (P < 0.05), and this increase was significantly greater than that in the subjects with either a predilection or antipathy for the green tea odor, or those subjects inhaling the water odor (time × treatment, P < 0.01). HFC in the...
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Change in the POMS test score after inhaling a low-intensity odor

Figure 9 shows changes in the scores from pre-inhalation to post-inhalation of the low-intensity odors for the six sub-scales of the POMS test. For the jasmine tea odor, all scores (except V) tended to decrease in the subjects with a predilection or antipathy for the jasmine tea odor. The score for V increased after inhalation of the jasmine tea odor in those subjects with a predilection for it.

When the subjects inhaled the green tea odor, the scores for T-A and V tended to decrease in those subjects with a predilection for the green tea odor and those with antipathy for it.

Discussion

The physiological and psychological effects induced by the inhalation of odors are thought to result from interactions between the physiological effects produced by the odor compounds and emotional effects that are dependent upon the subject’s preference for those odors. We divided 10 healthy volunteers into two groups with either a predilection or antipathy for each odor, and investigated whether the autonomic nervous response of those subjects with a predilection differed from that of the subjects with antipathy.

In the experiments with the high-intensity jasmine tea odor, the responses of the subjects with a predilection differed from those of the subjects with antipathy. The subjects with a predilection for the jasmine tea odor showed a decrease in heart rate and an increase in parasympathetic nervous activity after inhalation of the jasmine tea odor, and most of the negative mood scores in the POMS test decreased after inhalation of the jasmine tea odor. These results suggest that inhalation of the jasmine tea odor induced a sedative effect, both physiologically and psychologically, in those subjects with a predilection for the jasmine tea odor. In contrast, an increase in sympathetic nervous activity was observed, and most of the negative mood scores in the POMS test increased after inhalation of the jasmine tea odor by the subjects with antipathy for it. These results suggest that inhalation of the jasmine tea odor induced an excitatory effect physiologically and psychologically in those subjects with antipathy for it. These changes after inhalation of the jasmine tea odor are thought to have differed because of a difference in the emotional effects that depend on odor preference. In other words, the preference for an odor, which the subject evaluated immediately after inhalation, influenced the autonomic nervous activity. Consequently, variation in the subjects’ preferences produced different results. It is well known that sympathetic nervous activity is increased by various type of stress. In those subjects with antipathy for the jasmine tea odor, the sympathetic nervous activity was increased because the jasmine tea odor was recognized as a stressor, so no sedative effect was observed.

The experiments with the low-intensity jasmine tea odor showed no differences between the predilection and antipathy groups. In the subjects with both a predilection and antipathy for the low-intensity jasmine tea odor, a decrease in heart rate and an increase in parasympathetic nervous activity were observed, and most of the negative mood scores in the POMS test decreased after inhalation, suggesting that the low-intensity jasmine tea odor induced a sedative effect irrespective of the subject’s preference. The differences between the results from inhaling the high- and low-intensity jasmine tea odor are thought to have resulted from the difference in odor intensity that was evaluated by the subjects. Heuberger has reported that the pleasantness and intensity of an odor was correlated with a subjective evaluation of the mental state and autonomic nervous system parameters. Accordingly, the emotional effect arising from a predilection or antipathy for...
an odor did not influence the autonomic nervous activity because the low-intensity jasmine tea odor had little emotional effect. In the present study, the low-intensity jasmine tea odor was selected by subjective evaluation. The autonomic nervous response and POMS test scores were influenced more by the physiological effect of the odor compounds in the jasmine tea than by any emotional effect, and no difference that depended on the subject’s preference was apparent in experiments with the low-intensity jasmine tea odor. These results suggest that the odor compounds in jasmine tea induced an increase in parasympathetic nervous activity and a decrease in heart rate. When the subjects inhaled the high-intensity jasmine tea odor, the effects of the odor compounds were only apparent in those subjects with a predilection for the odor.

We also investigated whether the odor compounds in Chinese green tea, which is a basic ingredient of jasmine tea, had a sedative effect like that of the jasmine tea odor. In experiments with the low-intensity green tea odor, the change in POMS scores was similar to that with the low-intensity jasmine tea odor, except for V. However, the heart rate and autonomic nervous activity were not affected in either group. Therefore, the odor compounds in green tea induced a sedative effect that was psychological but not physiological, and only the jasmine odor compounds in jasmine tea contributed to an increase in the parasympathetic nervous activity and a decrease in heart rate. In experiments with the high-intensity green tea odor, a decrease in heart rate and an increase in parasympathetic nervous activity were observed in those subjects with a predilection for green tea, but not in those with antipathy for it. Most of the negative mood scores in the POMS test decreased after inhalation by those subjects with a predilection for the green tea odor, but did not decrease after inhalation by the subjects with antipathy for it. The effect of the high-intensity green tea odor depended on the subject’s preference, as was the case with the high-intensity jasmine tea odor, and emotional effects influenced the results of the green tea odor experiments. No increase in sympathetic nervous activity was apparent in the subjects with antipathy for the green tea odor. This result is attributed to the fact that green tea odor caused little stress to the Japanese subjects because it is more familiar than is the jasmine tea odor. Odors are believed to form a powerful connection with memories.26,27) The weak sedative effect observed on the subjects with a predilection for the green tea odor may have been due to an emotional effect that depended on preference or to the effect of the odor compounds in green tea which are thought to be weaker than those in jasmine tea.

Many researchers have reported the effects of the inhalation of various fragrances and their odor compounds, especially those of essential oils. For example, the activity of mice decreased after the inhalation of lavender oil and its main constituents, linalool and linalyl acetate.28,29) the subjects inhaling lavender oil showed increased beta power when assessed by electroencephalography, were less depressed when evaluated by the POMS test, reported feeling more relaxed, and performed arithmetic computations faster and more accurately.30) Saeki has reported that an increase in blood flow produced by a foot-bath was reinforced by the essential oil of lavender, and that relaxation-associated changes to the balance of autonomic nervous activity were delayed.31) In the light of these results, it is likely that inhaled odor compounds influence the function of the body to varying degrees. In the present study, the inhaled odor compounds of jasmine tea may have influenced the autonomic nervous system.

Odor information is conveyed to the anterior olfactory nucleus, the piriform cortex, and the anterior cortical amygdaloid nucleus via the olfactory nerve and the olfactory bulb, whence it reaches the hypothalamus related to the autonomic nervous system and the hippocampus related to the memory. Therefore, olfactory stimulation may influence autonomic nervous activity via the hypothalamus. Barraclough has observed that the spontaneous firing rates of neurons in the hypothalamus were accelerated by odor stimulation.32) Furthermore, the hypothalamus has a projection from the amygdala related to emotions. Therefore, emotions based on a preference for a particular odor may influence autonomic nervous activity via the amygdala and the hypothalamus.33) Robin has reported that the autonomic nervous response differed according to the subject’s preference for the eugenol odor, and that the difference in preference resulted from memories experienced by the subject.34) Nagai has reported that the inhalation of favorite odors suppressed sympathetic vasoconstrictor activity in the muscles and attenuated the blood pressure increase by affecting the central nervous system higher than the midbrain.35) In the present study, emotions based on a predilection or antipathy for the jasmine tea odor may have influenced the autonomic nervous activity through the amygdala and the hypothalamus, and consequently the autonomic nervous response differed according to these preferences.

In conclusion, the odor compounds in jasmine tea appeared to induce an increase in parasympathetic nervous activity and a decrease in heart rate, and to have a sedative effect. However, the stronger the intensity of the odor, the greater were the emotional effects induced, this depending on the subject’s preference for the odor of jasmine tea. The jasmine tea odor therefore had a sedative effect on those subjects with a predilection for it, but has no such effect on the subjects with antipathy for it.
References


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