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# Simultaneous Aromatherapy Massage with Rosemary Oil on Humans

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## Abstract

Massage of essential oils is increasing being used for the improvement of the quality of life and for the relief of various symptoms in patients, but scientific evaluation of the effects of fragrances in humans is rather scarce. The aim of this study was to investigate the effect of rosemary oil (*Rosmarinus officinalis* L., Labiatae) on human autonomic parameters and emotional responses in healthy subjects after transdermal absorption. Thirty five healthy volunteers participated in the experiments. Four autonomic parameters, i.e. blood pressure, breathing rate, pulse rate, skin temperature were recorded. Emotional responses were assessed by means of rating scales. Compared to placebo, rosemary oil caused significant increases of breathing rate, systolic blood pressure, and diastolic blood pressure which indicate an increase of autonomic arousal. At the emotional level, subjects feel more attentive, more alert, more vigorous, and more cheerful than before the administration of the oil. This finding suggests an increase of arousal in terms of self-evaluation. In conclusion, our investigation demonstrates the stimulating effect of rosemary oil and provides evidence for its use in medicines for the relief of depression and stress in humans.

## Keywords

*Rosmarinus officinalis* • Percutaneous absorption • Physiological parameters • Emotional parameters

## Introduction

The use of complementary medicines as an addition to traditional Western medical practice has significantly increased in many countries over the past decades. Aromatherapy is the fastest growing complementary medicine. Massage of essential oils is increasingly being used for the improvement of the quality of life as well as for the relief of various symptoms in patients [1–6], but scientific evaluation of the effects of fragrances in humans is rather scarce. Many researchers have attempted to prove the scientific effects of aromatherapy, most of the aromatherapy studies were not controlled studies and their results are therefore possibly biased and not scientific. Presently, there are a variety of approaches to evaluate the physiological and psychological effects of fragrances such as measuring changes in autonomic parameters, e.g. heart rate, breathing rate, blood pressure, eye-blinks, skin temperature and skin conductance [7–9], changes in brain wave activities, e.g. electroencephalogram, contingent negative variation [10–13], changes in mood, cognitive performances and emotion [14–17].

The interest in the use of essential rosemary oil (*Rosmarinus officinalis* L., Labiatae) as therapeutically active agent has grown considerably. Especially in aromatherapy, rosemary essential oil is used for mental strain or dullness and lethargy or exhaustion [18–19]. In addition, rosemary oil reportedly helps to strengthen the brain, to improve memory, and to fortify the heart. In animal studies, rosemary oil showed a stimulating effect by the increase in locomotor activity in mice after inhalation or oral administration of the substance. 1,8-Cineole is believed to be the active principle [20]. Furthermore, rosemary oil and its main components, i.e. camphor, 1,8-cineole, had a stimulating effect on the cerebral cortex of the rat *in vitro* [21]. A rosmarinic derivative (*O,O,N*-trimethyl-rosmarinic) has been demonstrated to exhibit significant smooth muscle stimulate effects *in vitro* [19]. In humans, rosemary oil showed a stimulating effect on the contingent negative variation brain waves after inhalation of the oil [22]. Rosemary oil, peppermint oil, and jasmine oil have been demonstrated to possess subjectively stimulating or arousing properties [11, 23]. Diego and colleagues reported the electroencephalogram (EEG) activity, alertness and mood on humans after inhalation of rosemary oil. Their results showed that a significant decrease in EEG frontal alpha power was found after inhalation of rosemary oil. These findings suggested an increased alertness/stimulation of the oil. Moreover, rosemary oil produced a significant enhancement of quality of memory and secondary memory factors in humans [15]. Atsumi et al. [24] showed that rosemary oil enhanced free radical scavenging activity and decreased the stress hormone, cortisol which protects the body from oxidative stress.

Although *Rosmarinus officinalis* L. essential oil is quoted extensively in many literatures as a stimulant, there have been relatively few published controlled studies of its efficacy in stimulating nervous system and emotional responses. Up to now, no experiments about the effects of rosemary oil on human autonomic parameters and on emotional responses after transdermal administration have been carried out. Therefore, the main objective of the present study was to investigate the effects of this fragrance compound on autonomic parameters as well as on emotional responses in healthy humans following transdermal absorption.

## Results and Discussion

In the present investigation rosemary oil was administered transdermally to healthy subjects. Autonomic parameters, i.e. systolic blood pressure (SBP), diastolic blood pressure (DBP), pulse rate (PR), breathing rate (BR), and skin temperature (ST), were recorded as indicators of the arousal level of the autonomic nervous system. In addition, subjects had to rate their mental and emotional condition in terms of relaxation, vigor, calmness, attentiveness, mood, and alertness in order to assess subjective behavioral arousal.

### Autonomic Parameters

The mean and SEM of autonomic parameters of the control group and the rosemary group are presented in Table 1.

**Tab. 1.** Mean and SEM of autonomic parameters of the control group and the rosemary group:

ANS parameters	Control (Mean±SEM)		Rosemary (Mean±SEM)	
	Trial 1	Trial 2	Trial 1	Trial 2
SBP	101.77±3.27	101.00±2.83	102.00±2.47	105.38±2.87
DBP	58.54±2.19	60.46±2.44	58.92±1.90	63.15±1.91
BR	16.83±1.07	15.74±1.12	16.78±1.24	17.75±1.62
ST	36.98±0.20	36.55±0.23	36.90±0.38	36.28±0.42
PR	68.07±1.76	66.20±1.84	68.16±2.72	64.21±2.27

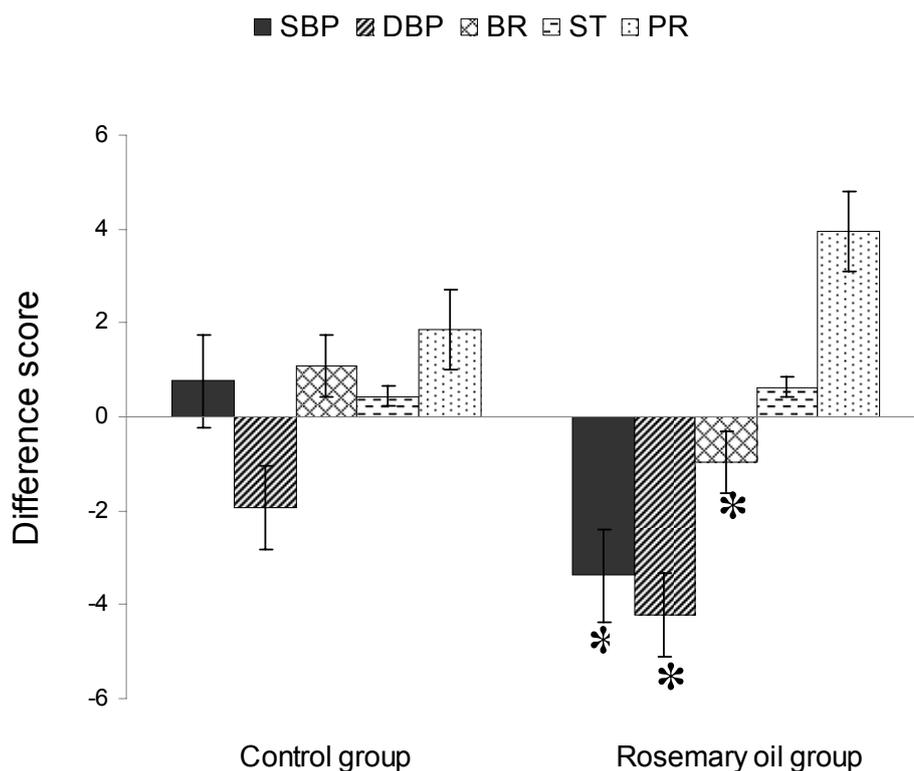
SBP: systolic blood pressure DBP: diastolic blood pressure, BR: breathing rate, ST: skin temperature, PR: pulse rate, SEM: standard error mean

SBP of subjects in the control group only marginally changed in the second trial compared with the first trial. In contrast, SBP of subjects in the rosemary oil group increased at the end of the second trial compared with the end of the first trial. The difference scores of SBP between the second trial and the first trial for the control group and the rosemary oil group are shown in Figure 1. Comparison of these difference scores revealed a significantly larger increase of SBP in the rosemary oil group than in the control group ( $P \leq 0.05$ ). DBP of subjects in the control and the rosemary oil groups increased at the end of the second trial compared with the end of the first trial. The difference scores of DBP between the second trial and the first trial for the control group and the rose oil group are shown in Figure 1. Comparison of these difference scores revealed a significantly larger increase of DBP in the rosemary oil group than in the control group ( $P \leq 0.05$ ). The rosemary oil caused a significant increase of blood pressure. Since blood pressure is determined by the activity of the sympathetic branch of the ANS, an increase of blood pressure shows an increase of sympathetic tone, i.e., an increase of autonomic arousal [25, 26].

BR of subjects in the control group decreased at the end of the second trial compared with the end of the first trial. In contrast, BR of subjects in the rosemary oil group increased in the second trial compared with the first trial. The difference scores of BR between the second trial and the first trial for the control group and the rosemary oil group are shown in Figure 1. Comparison of these difference scores revealed a significantly larger increase of

BR in the rosemary oil group than in the control group ( $P \leq 0.05$ ). Transdermal absorption of rosemary oil led to a significant increase of breathing rate. In general, the cardiovascular system has a relationship with the respiratory system. Muscle sympathetic nerve activity was associated with respiratory function, namely, an increase of respiratory rate leads to an increase of muscle sympathetic activity [27]. Furthermore, an increase of breathing rate may cause a decrease of baroreceptor sensitivity [28].

No significant effects of the rosemary oil on ST and on PR were found ( $P > 0.05$  for all).



**Fig. 1.** The difference scores of systolic blood pressure (SBP), diastolic blood pressure (DBP), breathing rate (BR), skin temperature (ST), and pulse rate (PR) for the control group and the rosemary oil group, \* on the top of the bars indicates significant differences ( $P \leq 0.05$ ).

### ***Emotional Parameters***

The mean and SEM of emotional parameters of the control group and the rosemary group are presented in Table 2.

**Tab. 2.** Mean and SEM of emotional parameters of the control group and the rosemary group.

Emotional parameters	Control (Mean±SEM)		Rosemary (Mean±SEM)	
	Trial 1	Trial 2	Trial 1	Trial 2
AT	22.31±3.33	26.75±4.13	23.87±3.34	17.60±2.41
AL	39.17±3.28	41.06±4.13	37.30±2.71	28.37±3.14
M	28.42±3.36	30.84±3.59	26.70±2.54	19.30±2.35
V	35.41±3.20	38.06±3.93	32.77±2.92	26.00±3.01
C	23.20±2.74	25.15±3.40	23.10±3.81	17.60±2.03
R	30.25±3.66	29.40±3.49	30.73±3.37	22.53±1.88

AT: attentiveness, AL: alertness, M: mood, V: vigor, C: calmness, R: relaxation, SEM: standard error mean

Subjects in the control group felt less attentive at the end of the second trial compared with the end of the first trial. On the other hand, subjects in the rosemary oil group judged themselves more attentive at the end of the second trial compared with the end of the first trial. The difference scores of subjective attentiveness between the second trial and the first trial for the control group and the rosemary oil group are shown in Figure 2. Comparison of these difference scores revealed a significant increase of subjective attentiveness in the rosemary oil group compared with the control group ( $P \leq 0.05$ ). Subjects in the rosemary oil group rated themselves more attentive than subjects in the control group. This finding points towards an increase of arousal in terms of self-evaluation [25, 26].

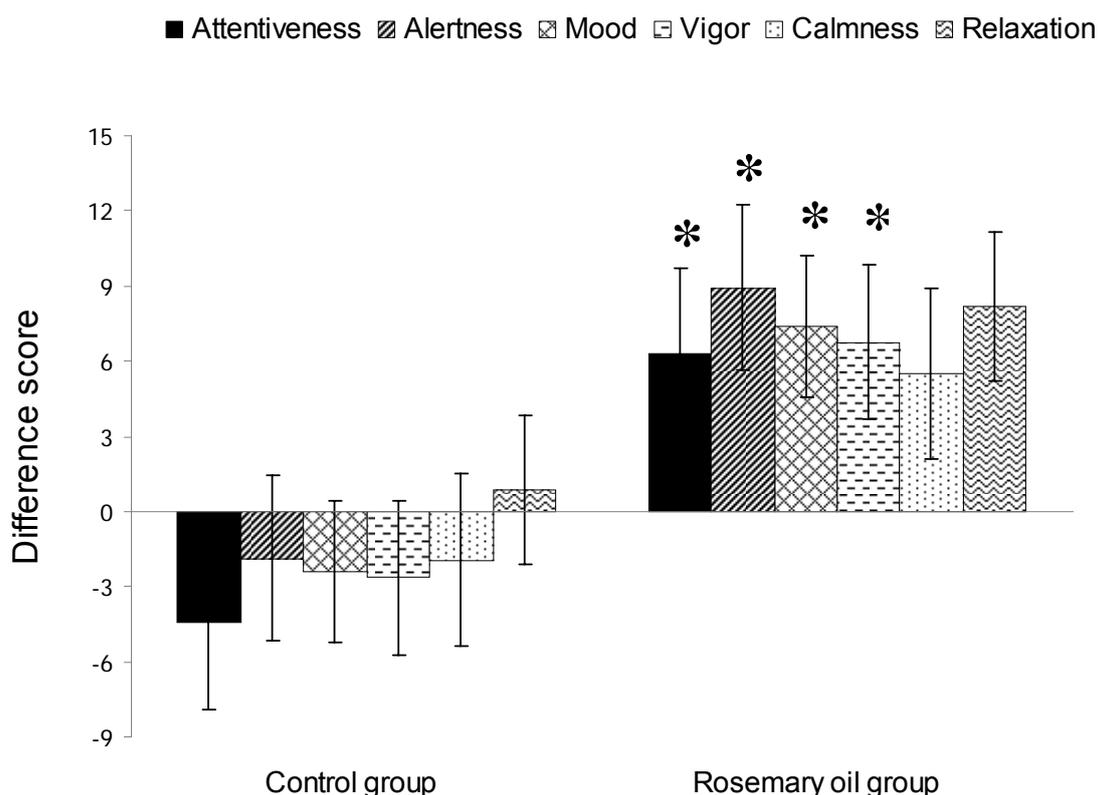
Furthermore, subjects in the control group felt less alert at the end of the second trial compared with the end of the first trial. On the other hand, subjects in the rosemary oil group judged themselves more alert at the end of the second trial compared with the end of the first trial. The difference scores of subjective alertness between the second trial and the first trial for the control group and the rosemary oil group are shown in Figure 2. Comparison of these difference scores revealed a significant increase of subjective alertness in the rosemary oil group compared with the control group ( $P \leq 0.05$ ). Subjects in the rosemary oil group rated themselves more alert than subjects in the control group. This finding points towards an increase of arousal in terms of self-evaluation [25, 26].

In addition, subjects in the control group felt less cheerful at the end of the second trial compared with the end of the first trial. On the other hand, subjects in the rosemary oil group judged themselves more cheerful at the end of the second trial compared with the end of the first trial. The difference scores of subjective mood between the second trial and the first trial for the control group and the rosemary oil group are shown in Figure 2. Comparison of these difference scores revealed a significant increase of subjective mood in the rosemary oil group compared with the control group ( $P \leq 0.05$ ). Subjects in the rosemary oil group rated themselves more cheerful than subjects in the control group. This finding points towards an increase of arousal in terms of self-evaluation [25, 26].

Moreover, subjects in the control group felt less vigorous at the end of the second trial compared with the end of the first trial. On the other hand, subjects in the rosemary oil group judged themselves more vigorous at the end of the second trial compared with the

end of the first trial. The difference scores of subjective vigor between the second trial and the first trial for the control group and the rosemary oil group are shown in Figure 2. Comparison of these difference scores revealed a significant increase of subjective vigor in the rosemary oil group compared with the control group ( $P \leq 0.05$ ). Subjects in the rosemary oil group rated themselves more vigorous than subjects in the control group. This finding points towards an increase of arousal in terms of self-evaluation [25, 26].

No significant effects of the rosemary oil on subjective calmness and relaxation were found ( $P > 0.05$  for all).



**Fig. 2.** The difference scores of subjective attentiveness, alertness, mood, vigor, calmness, and relaxation for the control group and the rosemary oil group, \* on the top of the bars indicates significant differences ( $P \leq 0.05$ ).

Transdermal absorption of rosemary oil increased the level of arousal of the autonomic nervous system (ANS), i.e. increases of systolic blood pressure, diastolic blood pressure, and breathing rate. Moreover, massage of rosemary oil lead to activation at the behavioral level, i.e. subjects feel more attentive, more alert, more vigorous, and more cheerful than before the administration of the oil. This finding points towards an increase of arousal in terms of self-evaluation. Thus, the effects of rosemary oil by means of percutaneous administration may be characterized by the concept of stimulating/activating effects which has also been described for sandalwood oil, kaffir lime oil, and the essential oil of *Citrus sinensis* [29–31]. In addition, our findings clearly support previous studies indicating the stimulating effect of rosemary oil [19–24].

Rosemary essential oil contains abundant oxides and monoterpenes, and has the main action of stimulating the nervous system under sympathetic control, leading to increase in alertness, attentiveness and concentrating abilities [32]. Heuberger et al. [33] described the effect of 1,8-cineole, the main component of rosemary oil, on the autonomic nervous system. Their results showed 1,8-cineole increased respiration rate after administration of the substance. Moreover, camphor, one of the constituents of rosemary oil, has been reported to stimulate activity of the central nervous system, respiration, and circulation [19, 21, 34] Furthermore, essential oils with a stimulating effect on the sympathetic activity, e.g. pepper oil, estragon oil and grapefruit oil, have been reported. These essential oils consist of some component, i.e. alpha-pinene and beta-pinene, which are possible that these components mediate the stimulating effect on the sympathetic activity. Therefore, it is possible that these components such as 1,8-cineole, camphor or alpha-pinene mediate the stimulating effect of the rosemary oil on the nervous system. Although our findings agree with other reports, it is important to further assess on biochemical measures (e.g., noradrenaline), as these measures further confirm the presence of a stimulating/activating effect.

Correlation analysis between the ANS and emotional parameters showed that the increases of blood pressure and breathing rate were not correlated with changes in emotional responses (data not shown). These findings suggest the effectiveness of pharmacological mechanisms, e.g. direct interactions between fragrance molecules and receptor sites which are involved in the regulation of ANS arousal. Due to its high lipophilicity fragrance molecule easily penetrate the blood brain barrier and enter to the brain following inhalation or massage [20, 35]. Therefore, one possibility that explains the stimulating effect of the rosemary oil could be that the oil possibly stimulates the locus ceruleus in the brain into releasing noradrenaline, a neurotransmitter that creates a stimulating/ activating effect. The locus ceruleus is also involved in arousal and activation [26, 36]. Another possibility that explains its effect could be that essential rosemary oil exerts its effects by an interaction with central (e.g. hypothalamic, limbic, thalamus) structures which control the level of autonomic and/or behavioral arousal. All our findings indicate that differential effects of the essential oils depend on mode/route of administration. Both pharmacological and psychological effects are active simultaneously when the oils are administered by means of inhalation and olfactory processing occurs. In contrast, percutaneous administration gives an evidence for pure pharmacological effect and exclusion of olfactory processing. Therefore, in order to differentiate between pharmacological and psychological effects of fragrances, subjective evaluation of the odors must be prevented [29–31, 37–42].

In conclusion, our investigation demonstrates the stimulating/activating effects of rosemary oil and provides evidence for its use in medicines for the relief of depression and stress in humans.

## **Experimental**

### ***Subjects and essential oil***

Thirty-five healthy volunteers aged between 18 and 48 years (mean age  $23.40 \pm 1.13$  years) took part in the experiments. Demographic data for the control group and the rosemary group are presented in Table 3. Subjects were tested in individual sessions and

randomly assigned to either the control group or the rosemary oil group according to random numbers. They were fully briefed, gave written informed consent to all aspects of the study and were free to withdraw at any time. Forty-eight hours prior to testing subjects were asked to abstain from food, beverages and toiletries containing the essential oil as well as from any stimulants (e.g. caffeine and nicotine). The experimental protocol was approved by the Srinakharinwirot University Ethic Committees and all procedures conformed to the Declaration of Helsinki.

**Tab. 3.** Demographic data for the control group and the rosemary group.

Parameters		Control group	Rosemary group
Number of volunteers		20	15
Sex (M:F)		8:12	7:8
Height (cm) (mean±SD)	Male	172.75±2.13	172.14±2.15
	Female	159.92±1.29	165.75±1.97
Weight (kg) (mean±SD)	Male	59.38±3.27	63.29±1.46
	Female	56.50±2.94	54.63±1.98

Rosemary oil was obtained by steam distillation from the fresh flowering top of *Rosmarinus officinalis* (available from Thai-China Flavours and Fragrances Industry Co., Ltd., Thailand). The oil was analyzed by the gas chromatography/flame ionization detector (GC/FID) and the gas chromatography/mass spectrometry (GC/MS). The oil mainly contains 1,8-cinole (50.88%), alpha-pinene (14.40%) and camphor (9.10%). The minor components are sabinene (7.12%), camphene (4.97%) and caryophyllene (2.45%).

### **Essential oil administration**

In the experimental group, 1 mL of a 20% (w/w) solution of rosemary oil in sweet almond oil was applied to the skin of the lower abdomen of each subject and the subjects self-massaged the oil into the skin for 5 min. Afterwards the massage area was covered with a plastic film in order to prevent evaporation of the oil. In the control group, 1 mL of the placebo oil, pure sweet almond oil, was used. In both groups subjects were supplied with pure air by breathing masks (inhalation set for adult, product no.1500004020, B+P Beatmungsprodukte GmbH, Neunkirchen, Germany) in order to eliminate any olfactory stimulation by nose or mouth.

### **Experimental protocol**

The experimental protocol has been previously described by our group [29–31, 37–42]. Briefly, one session consisted of two trials of 20 min each. At the beginning and at the end of each trial, emotional responses were assessed by visual analogue scales (VAS). Autonomic parameters were recorded continuously during each trial. In the first trial, which served as a control for influences of the experimental setup, the placebo substance was administered to all subjects. In the second trial the placebo was again administered to the control group, whereas in the experimental groups the appropriate fragrance was administered.

### ***Acquisition of autonomic parameters***

Breathing rate (BR), pulse rate (PR) and skin temperature (ST) were recorded simultaneously and in real time on the non-dominant side of the body. All parameters were measured using Power Lab/4SP hardware (ADInstruments, Inc., NSW, Australia) including sensors and Ag/AgCl surface electrodes. Sampling rate was 100 Hz. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured in the dominant arm by sphygmomanometry using an automated system (Digital Electronic Model DS-155E, Japan). Details of the recording system and procedure have been described elsewhere [29–31, 37–42]

### ***Acquisition of visual analogue scales (VAS)***

VAS were used to assess subjective mental and emotional condition. They consisted of 100 mm lines for six items: relaxation, vigor, calmness, attentiveness, mood and alertness. Each subject was asked to mark his or her feeling for each item between the two possible extremes: relaxed and tense for the item 'relaxation', vigorous and feeble for the item 'vigor', calm and restless for the item 'calmness', attentive and inattentive for the item 'attentiveness', cheerful and bad tempered for the item 'mood', alert and tired for the item 'alertness'.

### ***Procedure***

All experiments were conducted in a bright and quiet room. Ambient temperature was 24–26°C. Upon arrival, the volunteers were interviewed about their personal data, e.g. sex, age, height, weight. In addition, they were asked about the rating of emotional responses. After completion of the interview and the rating scales, systolic and diastolic blood pressure (SBP and DBP) were measured. Subsequently, subjects were seated in a semi-reclined position, providing easy access to attach the ANS electrodes or probes. BR was measured using a MLT415 surface temperature thermistor probe which registers breathing cycles on the basis of the difference in temperature between inhaled and exhaled air. The probe was placed at the entrance of the left nostril with non-caustic adhesive tape. PR was measured using a MLT1010 pulse transducer. The non-invasive pulse transducer was placed on the first phalanx of the ring finger with non-caustic adhesive tape. ST was measured using a MLT409 fast response thermistor. The sensor was placed on the middle of the back of the hand with non-caustic adhesive tape. The breathing mask was fitted to the volunteer's face to cover the nose and mouth. The oxygen was then supplied directly. The oil or the placebo were administered as described together with recording of the autonomic parameters. After completion of the first trial, the subjects were asked to rate the VAS. The systolic and diastolic blood pressures (SBP and DBP) were measured at the end of the first trial. This procedure was repeated in the second trial. At the end of each trial, the subjects were asked if they had perceived any odor during the experiment. All subjects stated that they did not perceive any odor during the experiment.

### ***Data and statistical analyses***

The autonomic recordings of each subject were computed by trial using Chart<sup>®</sup> software (ADInstruments, Inc., NSW, Australia). For each subject and every parameter the mean value in the second trial was subtracted from the mean value in the first trial to give the individual inter-trial difference score. For emotional ratings, on each scale the distance of the mark from the left-hand side was measured in mm. Individual difference scores

between ratings were calculated for each item. The Statistical Package for the Social Sciences (SPSS version 11.5) was used for statistical analysis. Mann-Whitney-*U*-Test analysis of variances was used in this study. The effects of fragrances on autonomic parameters and ratings of emotional responses were determined by comparing the difference scores between the control group and the experimental groups. Correlational analyses between ratings of emotional responses and autonomic parameters were performed by means of Spearman rank-order correlation coefficient.

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## **Author's Statements**

### ***Competing Interests***

The author declares no conflict of interest.

### ***Informed Consent & Ethical Approvals***

The institutional and (inter)national ethical guides for experiments on human subjects were followed and informed consent was obtained. See the experimental part for details.

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