Complementary Therapies in Medicine (2014) 22, 1027—1031

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Effects of olfactory stimulation with rose and orange oil on prefrontal cortex activity

Miho Igarashi [1], Harumi Ikei [1], Chorong Song, Yoshifumi Miyazaki *

Center for Environment, Health and Field Sciences, Chiba University, Kashiwanoha 6-2-1, Kashiwa, Chiba 277-0882, Japan

Available online 28 September 2014

KEYWORDS
Rose;
Orange;
Physiological relaxation;
Near-infrared spectroscopy;
Semantic differential method

Summary
Objectives: People have been aware of essential oils, which are derived from plants, for a long time. Recently, we have become interested in physiological and subjective effects of daily exposure to essential oils. The primary aim of the present study was to clarify effects of olfactory stimulation with rose or orange oil on prefrontal cortex activity; subjective evaluations of relaxation were also determined.
Setting and interventions: Subjects were exposed for 90 s to air impregnated with either rose or orange essential oil. As a control, subjects wore the same device but inhaled only unimpregnated air. The three stimuli were randomly presented to each subject.
Main outcome measures: Physiological effects were determined by near-infrared time-resolved spectroscopy and a modified semantic differential approach was used to determine subjective evaluations.
Results: The study participants were 20 female university students (mean age 22.5 ± 1.6 years). Olfactory stimulation by rose or orange oil induced: (1) a significant decrease in oxyhemoglobin concentration in the right prefrontal cortex and (2) an increase in ''comfortable,'' ''relaxed,'' and ''natural'' feelings.
Conclusion: These findings indicate that olfactory stimulation by rose or orange oil induces physiological and psychological relaxation.

Introduction

Physiological effects of natural environments and products have been of much interest in recent years. Forest therapy (walking in or viewing forests) has, for example, been demonstrated to induce relaxation effects in a number of field experiments.[1–5] However, modern civilization makes regular contact with natural environments difficult. Accordingly, the relaxation effects of natural products that can be used on a daily basis are of increasing interest.

* Corresponding author. Tel.: +81 4 7137 8184; fax: +81 4 7137 8008.
E-mail address: ymiyazaki@faculty.chiba-u.jp (Y. Miyazaki).
[1] Authors Igarashi and Ikei contributed equally to this work and are co-first authors.

http://dx.doi.org/10.1016/j.ctim.2014.09.003
0965-2299/

People have been aware of essential oils, which are derived from plants, for a long time. Recently, we became interested in the effects of daily exposure to essential oils as a natural therapy. Aromatherapy, which is the practice of using essential oils in a therapeutic context, is increasingly common and rose and orange oils are especially popular. Several studies have investigated the effects of these essential oils.

There have been relatively few studies of the physiological effects of rose odor on humans. Inhalation of the odor of rose oil was shown to decrease relative sympathetic activity as measured by heart rate variability and adrenaline concentration in healthy normal adult females.[6] In addition, Fukui et al.[7] reported that rose odor inhalation decreased salivary cortisol levels in healthy college students. Moreover, Fukada et al.[8] showed that inhaling the odor of rose essential oil inhibited increases in salivary cortisol and skin-barrier disruption in healthy female college students exposed to stress (university examinations). Regarding subjective evaluations of effects, Ayan et al.[9] showed that inhalation of the odor of rose essential oil is a useful supplementary and adjunctive therapy for relieving renal colic in renal colic patients.

In humans, the physiological effect of olfactory stimulation with the odor of orange essential oil, which is a subjectively pleasant odor, on P3 of the event-related potential (ERP), which concerns mental activity, is different from that of eugenol, which is a subjectively unpleasant odor.[10] Moreover, orange essential oil has been shown to reduce anxiety and improve mood in a dental office.[11] In addition, healthy female school-age children have been reported to be more likely to feel happy when smelling sweet orange essential oil.[12,13]

Previous studies of the effects induced by rose and orange oils have used several physiological and/or subjective indices. However, there has been no report of prefrontal cortex activity measured every second with near-infrared time-resolved spectroscopy (TRS). The TRS measurement is able to detect the absolute value of brain activity, and thus differs from other brain activity measurements.[14–16]

The aim of the present study was to clarify the effects of olfactory stimulation with rose or orange oil on left and right prefrontal cortex activity using near-infrared spectroscopy (NIRS) and also to determine the subjective effects of inhalation of the odors of these oils.

Methods

All study participants provided their written informed consent for participation after they were informed about the study's aims and procedures. The study was performed in accordance with the regulations of the Ethics Committee of the Center for Environment, Health, and Field Sciences, Chiba University, Japan. Physiological measurements were performed in a chamber with an artificial climate maintained at 25 °C with 50% relative humidity and 230 Lux illumination. In the artificial climate chamber, air is exchanged approximately every minute through ventilation. In this study, air was exchanged through ventilation approximately every 7 min and between treatments for each subject. We used rose essential oil (Tree of Life Co., Ltd.; *Rosa damascena*, product of Bulgaria, extracted from the flowers and subjected to solvent extraction) or orange essential oil (Tree of Life Co., Ltd.; *Citrus sinensis*, product of Brazil, extracted from the peels and compressed) as an olfactory stimulant and air as a control. Air impregnated with rose (0.2 μL) or orange (0.7 μL) essential oil was injected into a 24-L odor bag (polyethylene terephthalate film heat seal bag; NS-KOKEN Co., Ltd. Kyoto, Japan) and presented to each subject with a device that rested on the subject's chest approximately 10 cm under the nose (Fig. 1). The flow rate of the air impregnated with essential oil was set at 3.0 L/min. Preliminary investigations were used to determine subjective intensity to odor, for example, slight or weak sensation. The odor was administered for 90 s while the subjects sat with their eyes closed. The order of presentation of the three stimuli was random for each subject.

Physiological effects were determined by measuring oxyhemoglobin (oxy-Hb) concentrations in the prefrontal cortex using near-infrared TRS (TRS-20 system, Hamamatsu Photonics K.K.; [14–16]). The oxy-Hb concentrations in the left and right prefrontal cortex were measured at 1 Hz for 10 s before (pre-measurement condition) odor administration as well as during the 90 s of odor administration (post-measurement condition). Post-measurement values (every second) were compared with the pre-measurement value (mean 10 s) and differences determined. Differences were calculated based on absolute oxy-Hb concentration values and were not extrapolated since TRS enables detection of absolute values. Furthermore, we calculated a mean value per 90 s using differences in oxy-Hb concentrations. Data were transformed by linear interpolation because the 1 Hz sampling rate was only approximate.

In addition to the neurophysiological measurements, subjective evaluations of the emotional impact of the odors were determined using a modified semantic differential (SD) method.[17] Three pairs of adjectives were assessed on 13 scales, including ''comfortable—uncomfortable,'' ''relaxed—awakening,'' and ''natural—artificial.'' The SD rating test was performed after odor administration.

Statistical Package for Social Sciences software (V20.0; IBM Corp., Armonk, NY, USA) was used for all statistical analyses. A paired *t*-test with a Holm correction was used to compare physiological responses to the rose oil, orange oil, and control. Wilcoxon's signed-rank test with a Holm correction was applied to analyze differences in the psychological indices of responses to the rose oil, orange oil, and control. In both cases, one-sided tests were used because of the hypothesis that humans would be relaxed by the odor of rose or orange oil. The Holm correction was applied twice (i.e. a Holm correction was applied between the control and the rose oil and between the control and the orange oil).

Results

The study participants were 20 female university students (mean age, 22.5 ± 1.6 years). Time-dependent oxy-Hb concentration changes per 1 s in the prefrontal cortex during olfactory stimulation by rose essential oil, orange essential oil, and the control are shown in Fig. 2. The comparisons of the mean oxy-Hb concentrations in the prefrontal cortex per 90 s during olfactory stimulation by rose essential