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Ambient odor of orange in a dental office reduces anxiety and improves mood in female patients

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Abstract

Essential oils have been used as remedies for a long time in different cultures across the world. However, scientific proof of such application is scarce. We included 72 patients between the ages of 22 and 57 while waiting for dental treatment in our study. The participants were assigned to either a control group (14 men, 23 women) or to an odor group (18 men and 17 women). Ambient odor of orange was diffused in the waiting room through an electrical dispenser in the odor group whereas in the control group no odor was in the air. We assessed by means of self-report demographic and cognitive variables, trait and state anxiety, and current pain, mood, alertness, and calmness. In this study, we report that exposure to ambient odor of orange has a relaxant effect. Specifically, compared to the controls, women who were exposed to orange odor had a lower level of state anxiety, a more positive mood, and a higher level of calmness. Our data support the previous notion of sedative properties of the natural essential oil of orange (*Citrus sinensis*).

Keywords: Ambient odor of orange; Dental office; Anxiety; Mood

1. Introduction

Physiological and psychological effects of essential oils have been acknowledged in folk medicine and aromatherapy for a long time [22]. Citrus fragrances have been particularly attributed with mood-enhancing properties by aromatherapists and "successful experiments were carried out with oils of citrus fruits on patients affected with hysteria or depression" [15].

Based on such claims several researchers studied the psychological and physiological effects of citrus smells. Increased magnitude of the contingent negative variation (CNV) indicative of stimulation [4] for citrus notes was reported whereas decreased CNV magnitude indicative of relaxation was found for lemon [12]. Increased alpha band of micro-vibration and inhibited CNV suggesting mental relaxation [21] after orange odor exposure was found. Physiological studies documented changes in heart rate after lemon odor exposure [5]. Orange oil increased the activity of the parasympathetic nervous system by 12% and decreased the activity of the sympathetic nervous system by 16% [13]. Behavioral studies reported facilitated recall of a word list under lemon oil application [1] and a decrease in error rate in a letter cancellation task [13]. Using lemon odor in an environmental fragrance system that functions through the central air-conditioning system of a building, a significant reduction of key entry errors in video display operators was documented [12]. In a simulated retail environment, significantly different product evaluations and shopping behaviors were found under ambient orange scent as compared to a no scent condition [18].

Animals studies found evidence that citrus fragrance can restore stress-induced immunosuppression [17] and may have potential antidepressant effects in rats [10]. This result was followed up in a clinical study in patients with depression. A mixture of citrus oils was capable of reducing the necessary treatment doses of antidepressants, normalizing neuroendocrine hormone levels, and immune function in depressive patients [9]. Ambient lemon odor was also found to decrease the number of health symptoms in young healthy subjects [8].

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Given the potential of essential oils of altering physiological and psychological states, the goal of our study was to determine, in a natural setting of a waiting room, the effects of natural essential oil of orange on patients waiting for dental treatment. The setting of a dental waiting room was chosen because previous evidence suggested dental experience to be associated with fear and anxiety [6].

2. Materials and method

We included 72 patients between the ages of 22 and 57 in our study. The participants were assigned to either a control group (14 men, 23 women) or to an odor group (18 men and 17 women). Ambient odor of orange was diffused in the waiting room through an electrical dispenser in the odor group whereas in the control group no odor was in the air. The dispenser was hidden from the patients' view. Every morning and every noon approximately 0.25 ml, corresponding to five drops, of essential oil was applied to the diffuser. The natural essential oil of *Citrus sinensis* supplied by Primavera (Sulzberg, Germany) was used. The main components of the essential oil was determined by gas chromatography to be limonene 88.1%, myrcene 3.77%, and α-pinen 1.19%, all other components were below 1%.

We assessed education, cognitive functioning (intelligence quotient; IQ), pain (toothache), trait anxiety, state anxiety, mood, alertness, and calmness by means of self-report in the two study groups. Patients were selected randomly in order to control for different dental procedures (e.g., root canal drilling or dental cleaning). Upon arriving, patients were registered and then were handed the questionnaires to be filled in while waiting for treatment. The no-odor study group was tested first, followed by the odor group. Importantly, answering the questionnaires was entirely self-paced and dependent only on the speed of patients. We did not measure fill-in time but in no case was it longer than 20 min. Patients were told the purpose of the study was to determine the association between pain and mood. First, they completed a questionnaire asking for demographic data. For assessing cognitive functioning (IQ), patients completed the Wortschatztest (WST) [16] that is a standardized vocabulary test with good correlation to general intelligence as well as to education. Correlation coefficient between WST IQ score and education assessed as formal years of schooling was highly significant ($r = 0.60$, $p < 0.01$) in our study population. Next, they were asked about their current pain using an 11-point Likert scale ranging from 0 (no pain at all) to 10 (cannot take the pain anymore). Patients were next given a German version of the State–Trait Anxiety Inventory (STAI) [19], a self-report measure with demonstrated reliability and validity for assessing trait and state anxiety. High scores indicate high self-perceived anxiety. Subsequently, they were given the Mehrdimensionale Befindlichkeitsfragebogen (MDBF) [20] for assessment of current mood, alertness, and calmness. Patients had to answer questions regarding mood, alertness, and calmness on five-point Likert scales. Scale reliability (Cronbach's α) is above 0.9 for all three scales. Higher scores indicate more positive mood, high level of alertness, and high level of calmness.

Finally, in order to control for possible awareness of the presence of ambient orange odor patients were asked to compare the waiting room with different waiting rooms they may have encountered on four dimensions. Thus, patients were asked whether the waiting room is (i) higher/lower/not different in height, (ii) brighter/darker/not different, (iii) smells more pleasant/more unpleasant/not different, (iiii) has more newspapers/less newspapers/not different compared to other waiting rooms.

3. Results

We performed separate 2×2 analysis of variance (ANOVA) (group: odor vs. no-odor; sex: male vs. female). Statistical analyses indicated that the groups did not differ regarding education ($p > 0.2$), however, groups showed significant sex differences for IQ ($F(1,71) = 4.7$, $p < 0.04$) and a significant sex $\times$ group interaction for age ($F(1,71) = 4.3$, $p < 0.05$). Thus, in subsequent statistical analyses we included age and IQ as covariates. ANOVA for degree of toothache detected no statistical difference between groups ($p > 0.2$) indicating that all four groups were comparable in terms of pain rating. Statistical analysis for trait anxiety yielded a significant effect for sex ($F(1,71) = 4.6$, $p < 0.04$). No other effect was significant ($p > 0.7$ for all). For state anxiety there was no main effect of group ($p > 0.5$), nor sex ($p > 0.14$), however a significant group $\times$ sex interaction ($F(1,71) = 5.5$, $p < 0.03$) was detected. For the measure of mood there was no significant effect of group ($p > 0.4$). However, the effect of sex ($F(1,71) = 4.2$, $p < 0.05$) and the group $\times$ sex interaction were significant ($F(1,71) = 4.8$, $p < 0.04$). Statistical analyses of the dependent measure alertness showed no main effect of group ($p > 0.4$) nor a significant group $\times$ sex interaction ($p > 0.6$). The effect of sex ($F(1,71) = 4.86$, $p < 0.03$) was significant. For the measure of calmness there were no significant group or sex effects ($p > 0.30$ for all), however, a significant group $\times$ sex interaction ($F(1,71) = 6.9$, $p < 0.01$) was obtained. Visual inspection of significant interactions indicated less state anxiety, improved mood, and increased calmness between odor group and no-odor group only for women. Table 1 gives the details.

Awareness of presence of orange odor was analyzed with regard to no-odor group and odor group. Analyses for the no-odor group revealed that 5 (35.7%) of males reported "smells more pleasant", 1 (7.1%) male reported "smells more unpleasant", and 8 (57.1%) males reported "no difference", whereas 11 (47.8%) females reported "smells more pleasant", 3 (13.0%) females reported "smells more unpleasant", and 9 (39.1%) females reported "no difference", respec-

Table 1
Means, standard deviations, and the range of scores for each variable over the conditions

	No-odor group		Odor group	
Variables	Males	Females	Males	Females
Age[a]	31.4±4.2 (24–30)	34.6±9.7 (22–57)	38.2±9.6 (30–69)	32.5±9.7 (21–50)
IQ[b]	107.4±13.7 (80–129)	106.4±12.6 (80–129)	114.7±9.1 (99–129)	103.7±10.8 (81–125)
Pain	3.2±1.7 (1–6)	4.3±2.7 (1–10)	3.3±2.1 (1–7)	4.8±2.9 (1–10)
Trait anxiety[b]	33.4±5.0 (27–46)	39.0±10.2 (26–69)	33.5±6.9 (22–50)	38.2±11.7 (23–60)
State anxiety[a]	33.8±6.3 (26–46)	44.0±12.7 (24–67)	37.7±12.5 (24–62)	38.3±10.5 (21–60)
Mood[a,b]	34.4±2.8 (30–38)	29.0±6.1 (16–40)	33.0±5.8 (18–39)	31.9±6.4 (12–39)
Alertness[b]	29.6±4.3 (21–36)	25.9±6.9 (14–40)	29.7±7.1 (17–40)	27.4±6.9 (14–38)
Calmness[a]	31.8±3.6 (26–37)	25.9±7.8 (8–37)	29.4±7.9 (14–39)	30.1±6.8 (15–40)

[a] Interaction sex × group: $p<0.05$.
[b] Sex effect: $p<0.05$.

tively. There was no significant statistical differences between males and females ($\chi^2=1.19$; $p>0.55$). Analyses for the odor group revealed that 7 (38.9%) of males reported "smells more pleasant", 1 (5.6%) male reported "smells more unpleasant", and 10 (55.6%) males reported "no difference", whereas 8 (47.1%) females reported "smells more pleasant", 1 (5.9%) females reported "smells more unpleasant", and 8 (47.1%) females reported "no difference", respectively. There was no significant statistical differences between males and females ($\chi^2=0.26$; $p>0.88$). The subjects have not been asked directly, if they had smelled on odor of orange in the waiting room. They also have not been asked whether they detected the odor of eugenol.

4. Discussion

The results of this study indicate that exposure to ambient odor of orange has a relaxant effect. Specifically, compared to the controls, women who were exposed to orange odor had a lower level of state anxiety, a more positive mood, and a higher level of calmness.

The finding of a sex effect was unexpected because it has been rarely described in the literature. One explanation could be that this phenomenon has received little scientific attention until now, with only a few studies exploring sex effects. For instance, performance accuracy in a sustained attention task was improved after peppermint and muguet exposure only in female subjects [23] and lingering time in a jewelry store was different under scent application for males and females [7]. However, given prior reports indicating sex differences for olfactory sensitivity, odor identification, and odor memory (reviewed in Ref. [11]), our finding may be due to sex differences in olfactory perception. A recent study demonstrated gender effects on odor-stimulated functional magnetic resonance imaging indicating more brain activation in women compared to men after odorant application [24]. This finding supports the behavioral data and suggests physiologic differences between men and women for olfactory perception.

Some sort of masking process may have been responsible for the detected effect. The greatest sources of fear in dental treatment are the anesthetic needle and the drill [6]. The dental office is very often impregnated with the smell of eugenol, since eugenates (cements containing eugenol) are used in restorative dentistry on vital teeth. Eugenol odor may be negatively associated with dental care in some patients and thus may evoke intense unpleasant feelings such as anxiety and fear. This is supported by the finding that in patients with dental phobia the "smell of the dental office" is given high importance [2]. Increased emotional responses to eugenol in dental phobic patients measured by psychophysiologic methods using autonomic nervous system parameters [14] indicated a possible connection between fear of pain and the smell of eugenol. The reduced state anxiety, raised mood, and increased calmness found in our study could thus be due to the masking of negatively charged eugenol odor in female patients. In male patients olfactory influence on anxiety could play a minor role perhaps because of their lesser olfactory sensitivity.

The observed effect could have been due the conscious perception of the smell with the presence of the odor in the office being a source of shared attentional resources, serving as an orienting stimulus, and thus distracting patients from attending to their internal bodily states. If this is the case, the specificity of such an olfactory response should be compared to other stimuli (e.g., music) in future studies. Patients could have also formed some hypothesis regarding the odor even though no overt reference to the odor is made in the presence of the subjects. However, as awareness analysis of presence of odor showed males and females had a very similar distribution of "smells more pleasant/smells more unpleasant/not different" responses in the odor group indicating that conscious perception cannot account for the results.

There are several limitations of the study that should be addressed in future studies. First, since the odorant was applied to the diffuser two times a day, it is possible that the largest effects were seen during the times of the day when the odorant concentration was at its highest and as a consequence if more females were scheduled for dental

work at those times of the day, gender effects might be explained by this. Second, our patients were not screened for upper nasal infection, allergies, etc.; however, the patients sample likely contained patients with nasal disease. As patients were assigned randomly to the experimental conditions we assume that nasal disease status was similar across conditions. However, screening would be helpful in detecting nasal disease status. Third, as patients expect to undergo different dental procedures (e.g., root canal drilling, dental cleaning) they will likely have different baseline anxiety. Unfortunately, in the current study we have no such information available. Such procedures should be documented and correlated to odor effects in future studies. Fourth, in our study we did not measure physiological changes induced by psychological stress directly. Measuring levels of cortisol by way of saliva sampling as an indicator of psychological stress could be helpful in detecting physiologic effects of ambient odor. Fifth, it has to be determined whether the reduction of anxiety in the waiting room will also reduce anxiety when seated in the dental chair.

In conclusion, our study supports the traditional use of essential oils in altering emotional states. However, future studies should also take up the suggestions of Jellinek [3] and investigate direct effects of odorant molecules upon the central nervous system, effects of odorant mixtures, as well as those of single odor molecules, and effects of natural odor mixtures compared to synthetic products.

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