Original Article

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Physiology Section

Effect of Fragrance on Electroencephalographic Waves and Blood Pressure during Problem-solving Activity among Healthy College Students: A Cross-sectional Study

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ABSTRACT

Introduction: The influence of fragrance, such as perfumes and room fresheners, on the psycho-physiological activities of humans has been known for a long time. However, very few studies have been conducted to investigate its effects when a person is under stress.

Aim: To determine the effect of fragrance on electroencephalographic waves and blood pressure during a problem-solving activity.

Materials and Methods: This cross-sectional study was conducted among 55 college students aged 18-22 years in the electrophysiology laboratory of the Department of Physiology at Pondicherry Institute of Medical Sciences, Puducherry, India from May 2019 to June 2019. After obtaining a history and conducting an olfactory examination, participants were asked to be in the electrophysiology laboratory to record Electroencephalogram (EEG) and blood pressure before and after exposure to fragrance for five minutes. Data were statistically analysed using Fischer's-exact test and paired t-test.

Results: The study included 55 college students (38 males, 17 females) with a mean age of 19.46±1.004 years. EEG changes were compared at rest, including alpha waves (n=55), beta waves (n=55) during the problem-solving activity, and theta waves (n=55) during exposure to lavender fragrance. EEG changes were analysed using Fischer's-exact test, and the results were statistically significant (p-value <0.001). The mean±Standard Deviation (SD) of Systolic Blood Pressure (SBP) during fragrance exposure (110±11.82 mmHg) vs solving the puzzle (123.44±15.97 mmHg) was significantly lower (p-value=0.048*). The mean±SD of Diastolic Blood Pressure (DBP) during fragrance exposure (74.44±11.27 mmHg) vs solving the puzzle (74.40±12.92 mmHg) was slightly higher, but not statistically significant (p-value=0.516).

Conclusion: The present study demonstrated that the use of fragrance can have a relaxing effect on the mind and body, as it increases theta wave activity in the brain and significantly reduces SBP.

Keywords: Electroencephalogram, Mind relaxation, Perfumes, Puzzle solving

INTRODUCTION

The psychophysiological activities of humans are affected by fragrances used in perfumes and room fresheners. Over a few decades, these facts have been utilised as a key for aromatherapy. Each fragrance has a volatile chemical with a molecular weight of less than 300 Da, which humans can perceive through olfactory receptors, and they play a vital role in physiological effects on stress, working capacity, and mood [1].

These aromatic components in fragrances have been used in ancient civilisations to heal many disorders such as headache, pain, insomnia, stress-related anxiety, and digestion problems [2]. These volatile chemical components attach to G-protein coupled receptors, which transmit electrical signals to the olfactory bulb and olfactory cortex [3]. Researchers have found that the inhalation of fragrance compounds is able to cross the blood-brain barrier and interact with receptors in the central nervous system, producing an immediate effect on blood pressure, heart rate, and EEG [4]. Studies have shown that lavender oil is commonly used in aromatherapy due to its calming effect produced by ingredients such as Geraniol, Linalvol, Linalyl Acetate, and Beta Caryophyllene [5].

The EEG is a quantitative measure of the physiological state of the brain, both in health and disease. By using computer software, EEG recording provides topographic mapping of brain activity in the frontal, temporal, parietal, and occipital regions [6]. In the psychophysiological properties of aroma, lavender is the most studied fragrance. There are four important lavender species: L. angustifolia, L. stoechas, L. latifolia, and L. intermedia [7]. Lavender is the most common fragrance used in aromatherapy, including inhalation, massage, oil application, and bathing. It has anxiolytic, neuroprotective, and mood stabilising properties [8]. Aromas not only affect EEG but also alter blood pressure and heart rate via the autonomic nervous system. Hence, the inhalation of fragrance has been used in the treatment of hypertension [9]. Studies have shown that the blood pressure and heart rate of palliative care patients have decreased significantly compared to placebo trials [10].

However, there is a paucity of data on how fragrances alter EEG activity of the brain and blood pressure when individuals are actually under stress, and whether the relaxing effect occurs when the brain is involved in problem-solving activities. Therefore, the present study was conducted to determine the effect of fragrance on EEG and blood pressure while individuals are involved in problem-solving activities.

MATERIALS AND METHODS

The present cross-sectional study was conducted in the Electrophysiology Laboratory, Department of Physiology at Pondicherry Institute of Medical Sciences, Puducherry, India, over a period of two months, from May 2019 to June 2019. The study commenced after obtaining Institutional Ethical Clearance (IEC no: RC/19/25). Written informed consent was obtained from all participants.

Inclusion criteria: A total of 55 right-handed, healthy college students (both male and female), aged between 18-22 years, with normal Body Mass Index (BMI), were included in the study after performing an olfactory examination as follows: each nostril was tested separately by placing stimuli under one nostril and occluding the opposing nostril. The stimuli used were non-irritating and identifiable. Some example stimuli included coffee powder, asafoetida, cinnamon, and cloves to test the sense of olfaction.

Exclusion criteria: Participants with a known history of head injury, allergies, epilepsy, migraines, sleep disorders, drug abuse (nicotine, alcohol, and opium), evidence of infection, or any systemic disease were excluded from the study.

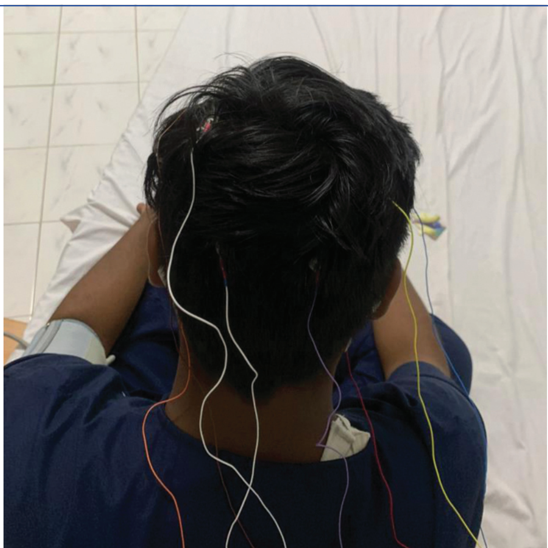
Sample size: The sample size was calculated using 'N' Master software, Christian Medical Centre, Vellore, based on mean±SD from the study done by Ojha P et al., with a power of 80%, alpha error of 5% for a two-sided hypothesis, and a 10% attrition rate. The estimated sample size was 55 [11].

To avoid bias, the poster was put up on the college notice board and an e-poster was circulated through mobile. Whoever was interested was chosen as participants.

Study Procedure

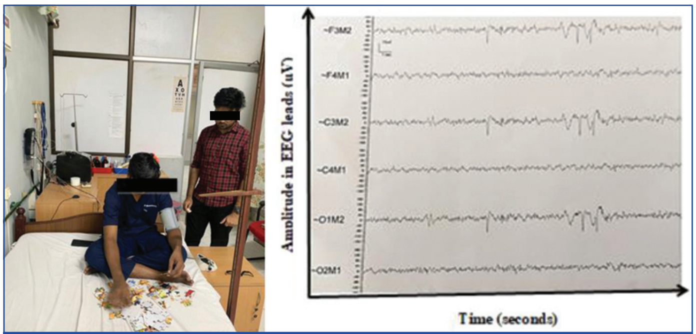
Participants were selected after taking a history of common cold, seizures, allergies to lavender fragrance, and general examination including consciousness, alertness, orientation to time and place. Vitals such as baseline pulse and blood pressure were checked, and height and weight were measured. This was followed by a central nervous system, cardiovascular, and systemic examination. Participants were advised to get adequate sleep the night before recording. They were asked to wash their hair with shampoo on the day of the test and to avoid applying oil, gel, or spray on the scalp before recording. Participants were instructed not to use perfumes/ deodorants on the day of recording and to avoid exercise, yoga, meditation, coffee, tea, alcohol, and smoking for atleast eight hours before the study.

The study participants were asked to report to the Electrophysiology Laboratory at around 5 pm. The entire procedure took approximately 20 minutes for each participant. A 6-EEG electrode was placed based on the 10-20 electrode placement system, as per the American Academy of Sleep Medicine guidelines (AASM) [12]. Participants were made to rest in a sitting posture, with their arms resting on the table and feet flat on the ground, and their eyes closed for five minutes while the EEG was recorded [Table/Fig-1] using the Alice-5 polysomnograph system. Simultaneously, blood pressure was recorded using a digital device - OMRON HEM-7130 (OMRON Healthcare Co., Ltd.).



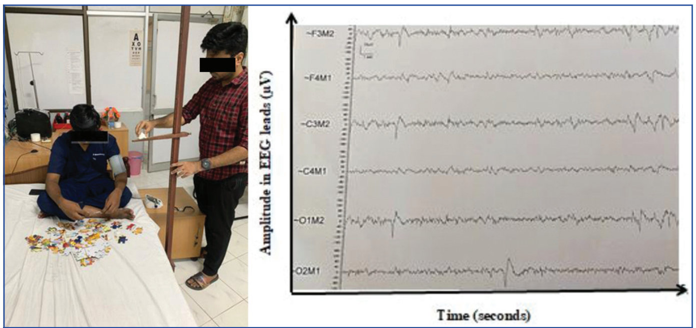
[Table/Fig-1]: Shows EEG placement using 10-20 electrode placement system.

The EEG waves have different frequencies, such as delta waves (0.5-4 Hz) recorded during non REM sleep, theta waves (4-8 Hz) which occur during a drowsy state and creative thinking, alpha waves (8-13 Hz) during a calm and alert state, beta waves (13-30 Hz) during problem-solving activities, and gamma waves (30-50 Hz) during working memory tasks [6]. Subsequently, the participants were asked to solve a given jigsaw puzzle [Table/Fig-2a,b], which involves both mental and physical involvement, where puzzle pieces need to fit into a particular location and the participant needs to analyse whether a piece will fit or not [13].



[Table/Fig-2]: a) Recording EEG and blood pressure while solving Jigsaw puzzle. b) EEG recording showing beta waves while solving Jigsaw puzzle. (Images from left to right)

Blood pressure and five minutes of EEG were recorded during the puzzle-solving activity. After the recording, while the participant continued to solve the puzzle, a disposable cotton ball soaked in 10 drops of lavender oil (Aromark personal care) was placed on a stand approximately 15 cm in front of the participant's nose [14]. Blood pressure and five minutes of EEG recording were done again [Table/Fig-3a,b]. The EEG waveforms and blood pressure of the participants were tabulated in excel.



[Table/Fig-3]: a) Recording of fragrance effect on EEG and blood pressure while solving Jigsaw puzzle. b) Effect of fragrance on EEG recording showing theta wave while solving Jigsaw puzzle. (Images from left to right)

STATISTICAL ANALYSIS

The SPSS software version 20.0 was used for data analysis on the effect of fragrance on EEG waves during problem-solving activity using Fischer's-exact test. Paired t-tests were used to analyse the effect of fragrance on blood pressure during problem-solving activity.

RESULTS

The present cross-sectional study was conducted among 55 participants (males=38, females=17) in the Electrophysiology Laboratory, Department of Physiology. The mean age of the participants was 19.46±1.004 years, with a mean BMI of 23.12±3.99 kg/m^2. The mean baseline heart rate was 83.11±1.32 beats/ min. The mean baseline systolic and diastolic blood pressures were 112.44±12.32 mmHg and 72.82±7.73 mmHg, respectively [Table/Fig-4].

Demographic parameters	Mean±SD
Age (years)	19.46±1.004
BMI (kg/m^2)	23.12±3.99
Baseline heart rate (beats/min)	83.11±1.32
Baseline Systolic Blood Pressure (SBP) (mmHg)	112.44±12.32
Baseline Diastolic Blood Pressure (DBP) (mmHg)	72.82±7.73

[Table/Fig-4]: Demographic details of the study participant.

In the present study, EEG changes were compared at rest, during problem-solving activity, and exposure to lavender fragrance. Beta waves were recorded in both the right and left frontal, central, and occipital regions for the participants while solving the jigsaw puzzle. However, upon exposure to lavender oil fragrance while solving the puzzle, the EEG pattern changed from beta waves to theta waves in both the right and left frontal, central, and occipital regions for all 55 study participants [Table/Fig-5].

Variables	EEG waveform (n=55)					
	Frontal		Central		Occipital	
	Right	Left	Right	Left	Right	Left
At rest with eyes closed	Alpha	Alpha	Alpha	Alpha	Alpha	Alpha
Problem-solving activity	Beta	Beta	Beta	Beta	Beta	Beta
Exposure to lavender fragrance	Theta	Theta	Theta	Theta	Theta	Theta

[Table/Fig-5]: Effect of fragrance on EEG waveform during problem-solving activity.
Fisher's-exact test: p-value <0.001; statistically significant

The mean SBP increased during the puzzle-solving activity but showed a reduction during fragrance exposure, with the decrease being statistically significant (p=0.048). Similarly, the mean DBP increased during the puzzle-solving activity but showed a further increase during fragrance exposure. However, this increase was not statistically significant (p=0.516). The mean values of SBP and DBP at rest, during puzzle-solving, and during fragrance exposure were represented in [Table/Fig-6].

Blood pressure (mmHg)	At rest	Solving puzzle (mean±SD)	During fragrance exposure (mean±SD)	p-value (paired t-test)
Systolic Blood Pressure (SBP)	112.40±12.32	123.44±15.97	110±11.82	0.048*
Diastolic Blood Pressure (DBP)	72.82±7.73	74.40±12.92	74.44±11.27	0.516

[Table/Fig-6]: Effect of fragrance on systolic and diastolic blood pressure during solving puzzle and during fragrance exposure.
Statistically significant

DISCUSSION

In the present study, lavender fragrance was administered to 55 healthy participants. Inhalation of lavender oil significantly calmed brain activity, as confirmed by an increased recording of theta waves along with a simultaneous decrease in SBP, indicating reduced sympathetic activity. These results are consistent with previous studies indicating that lavender odour can have a relaxing effect on brain activity [15].

The evidence of relaxation on EEG can be observed through various methods such as meditation, which is known to balance the body and mind and induce feelings of peace and relaxation [16]. EEG findings in individuals who meditate show an increase in theta waves, similar to those observed in individuals exposed to lavender inhalation [17,18].

A study by Benarroch EE, et al., demonstrated an association between EEG and olfaction [10]. Jackson AF and DJ Bolger AF, provided new information on how odour signals are processed by the brain through EEG recordings [19]. A study using a combination of Tai Chi and yoga showed that the treatment had relaxing effects, as confirmed by an increase in theta activity in EEG recordings [20]. Iijima M et al., showed that exposure to unpleasant smells leads to cortical deactivation by increasing alpha power compared to pleasant odours [21]. Skoric MK et al., suggested that lavender oil inhalation significantly decreases alpha activity, which is highly correlated with a comfortable state of subjects [22]. Studies have also shown that lavender aroma decreases alpha activity in the occipital and parietal regions while increasing theta activity [23]. Furthermore, inhalation of lavender oil resulted in subjects feeling fresher and more relaxed compared to those inhaling a base oil, and lavender oil increased theta activity compared to the base oil [24].

In the present study, lavender fragrance inhalation significantly reduced SBP, which is consistent with previous studies conducted by Woronuk G et al., and Koulivand PH et al., [25,26]. It has been reported that the effects of fragrance inhalation on autonomic nervous system parameters, such as blood pressure, are partially influenced by the mental and emotional effects caused by olfactory stimulation [25,26]. These psychological responses to an odorant may also be influenced by acquired experiences and memory. Pleasant fragrances may induce relaxation of the mind, resulting in a decrease in sympathetic activity [27].

Another possibility that explains the effects of fragrance on blood pressure could be the pharmacological action of essential oil components [15,16]. A study by Nagai K et al., showed that inhalation of lavender odour during physical exercise among college students suppressed muscle sympathetic vasomotor activity, thereby increasing diastolic blood pressure [27]. Studies have shown that an increase in diastolic blood pressure correlates with a change in the frequency of muscular sympathetic nerve activity [28]. Aromatic substances can increase diastolic blood pressure by affecting autonomic neurotransmitters and decrease SBP due to a decrease in plasma Adrenocorticotropic Hormone (ACTH) levels, resulting from decreased activity of the hypothalamic-pituitary-adrenal axis [29].

Limitation(s)

Diurnal variation in task performance was not ruled out in the study. It is generally known that the olfactory sense causes adaptation to odours, meaning that the perception of odours is strong initially but diminishes when the same odour is continuously presented. In the present study, the occurrence of adaptation to odours was not taken into account in the analysis, as the effects of adaptation could not be quantified.

CONCLUSION(S)

The present study demonstrates that the use of fragrances, such as essential oils like lavender, can induce a relaxing effect on the mind. This is supported by the increased brain theta activity and decreased systolic blood pressure observed during problem-solving activities, indicating the refreshing and positive effects of aromatherapy. However, the present study has some limitations. The effect of fragrance on EEG may vary with different concentrations and durations of exposure. Therefore, it is still unclear whether the findings of the present study will hold true for EEG and blood pressure with different concentrations and a larger number of participants. Standardising and developing a common standard operating procedure can provide a better understanding of the effects of fragrance on EEG and blood pressure.

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