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# UNVEILING THE SCENTED SYMPHONY: EXPLORING LEMONGRASS (*CYMBOPOGON CITRATUS*) ESSENTIAL OIL'S INFLUENCE ON BRAIN WAVES THROUGH QUANTITATIVE ELECTROENCEPHALOGRAM

**Israt Jahan[1*], Esaba Sadia[2], Sultana Ferdousi[3].**

## ABSTRACT

**Background:** This study explores the captivating query about how olfactory stimulation affects neural activity, particularly examining changes in the absolute and relative power of lower frequency waves (delta and theta across various brain regions). This investigation employs Quantitative Electroencephalogram (QEEG) to analyze the effects of exposure to the aroma of lemongrass (*CymbopogonCitratus*) essential oil. **Aim:** To evaluate the impact of inhaling lemongrass (*CymbopogonCitratus*) essential oil aroma on EEG patterns in awake healthy female adults, employing power spectral analysis. **Materials and Method:** In this self-controlled experiment, 30 healthy adult female participants were exposed to the water mist as control and after taking baseline recording, they inhaled aromatic mist from room air, and again brain activities were recorded using QEEG. Data was collected from scalp electrodes readings and outcomes from before and after exposure to the aroma were compared. This analysis was strengthened by comparing the results between exposure to water mist and oil mist employing the Wilcoxon Matched-Pairs Signed Rank Test. **Results:** Significant elevation of absolute and relative power of theta in prefrontal region ($p$=0.002; $p$=0.000) along with rise of delta and theta absolute power in frontal area ($p$=0.000;$p$=0.000) was observed. **Conclusion:** This study sheds light onto the background oscillatory fluctuations in lower frequency bands that may indicate more relaxed state of brain activity due to inhalation of lemongrass essential oil.

**Keywords:** Lemongrass essential oil, Olfactory stimulation, Quantitative EEG, Delta and theta brain waves, Absolute and relative power.

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## INTRODUCTION

In recent years, there has been a growing interest in the therapeutic potential of essential oils for enhancing cognitive function and emotional well-being. Scientists are giving acknowledgement to one of our unique senses, olfaction, which possesses a remarkable capacity to elicit powerful emotions, and modulate cognitive states[1]. An intriguing scent that has emerged as a focal point of investigation is lemongrass (*CymbopogonCitratus*) essential oil (LEO), renowned for its invigorating fragrance and historical use in traditional medicine[2]. One study observed a calming yet alert state following inhalation [3], while another study reported contrasting findings, suggesting a profound relaxation effect[4].

1*. Department of Physiology, Armed Forcess Medical College, Dhaka Cantonment, Dhaka, Bangladesh. Email: jahanisrat640@gmail.com [Address of correspondence]

2. Department of Physiology, Ibrahim Medical College, Shegunbagicha, Dhaka, Bangladesh.

3. Department of Physiology, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh.

Scientific research exploring its effects on brain activity remains limited, particularly concerning its influence on specific brain wave patterns. Quantitative EEG, recognized worldwide among researchers for its precision and reliability, offers a quantitative assessment of brain electrical activity. This non-intrusive method captures and examines electrical brain signals through the application of the Fast Fourier Transformation algorithm. This analysis provides valuable understanding of how the brain's rhythmic patterns evolve in reaction to external stimuli, presenting data in numerical terms such as absolute and relative power. Absolute power represents the total energy within a specific frequency band, while the relative power denotes the percentage of total power within the EEG signal attributed to that band[5].

Despite the widespread belief that delta rhythm (0.0-4.0 Hz), with high-amplitude but low-frequency fluctuations, in awake human EEG is primarily linked to sleep, study suggests that its activity can prevail in the background operation and functioning of certain brain regions in awake individuals[6]. On the other hand, theta (4.0-8.0 Hz) waves are correlated with improved memory retrieval, innovative thinking and imaginative mental projection[7]. Analysis of these two frequencies may serve as crucial indicators of mental state and cognitive processing.Our exploration holds promise in revealing the mechanisms underlying the cognitive effects of aromatic stimulation, offering valuable information about the intersection of scent and brain functions.

## MATERIALS AND METHOD

This self-controlled trial took place in the Physiology Department of Bangabandhu Sheikh Mujib Medical University (BSMMU) from March 2022 to February 2023. Ethical clearance was obtained from the Institutional Review Board of BSMMU prior to commencement.

### *Participants*

Healthy adult female volunteers were recruited via poster advertising at the BSMMU campus, with thirty participants selected based on specific criteria: 1) aged between 25 and 38 years; 2) right-handed, tested by Edinburg Handedness Inventory scale (EHI)[8]; 3) non-smokers and abstaining from alcohol; 4) devoid of any history of neurological disorders affecting olfaction; 5) not consuming hormonal contraceptives or drugs affecting the central nervous system[9].Additionally, a screening test using the n-butyl alcohol test ensured normal olfactory function (mean score 10.3 $\pm$ 0.70). A general physical examination was conducted, which included assessing Body Mass Index (BMI), resting pulse and blood pressure. Prior to the experiment, participants provided informed written consent and received a preparation manual. As there is connection between brain function with level of aroma pleasantness in different individuals, participants rated the aroma's pleasantness on a 5-point Likert scale. Only those rating the aroma as pleasant within 2-4 points, permitted to proceed with the experiment.

### *Experimental design*

Initially, participants underwent a 'no aroma' session by using water mist, serving as a control session, in a controlled environment (temperature: 23-25°C, dark room, humidity: 40-50%), before and after which their neural activity was measured using QEEG. Subsequently, following an interval, exposure to the aroma of LEO was done, and recording was taken thereafter.

### *Procedure*

Each participant comfortably sat in a soundproof room, and EEG electrodes were attached to the scalp using the international 10-20 system. The gain was set at 7.5 μv/mm. Analogue-to-digital conversion was 24 bits, the notch filter was open at 50 Hz, sampling rate was 1024 Hz.

The impedance was adjusted to 5 KOhm[10]. Baseline EEG measurements were taken for 02 minutes. Then ultrasonic aroma diffuser[11] released water mist and the subject inhaled for 20 minutes and an EEG recording was done. After a short interval, LEO was diluted in a 1:1000 ratio with water, diffused into the room air in the same manner, and participants inhaled the scent for 20 minutes. Immediately after exposure, EEG measurement was done for another 02 minutes.

### *Data Analysis*

In each recording during the baseline and post-exposure periods, 60-second EEG waves were analyzed using specialized software (BrainTech 40+ Standard version 4.47a) that calculates absolute and relative power frequencies of delta and theta waves. Data were expressed in median (IQR), and the Wilcoxon Matched-Pairs Signed Ranks Test was conducted to compare pre-exposure values to post-exposure values and determine significant alterations in absolute and relative power of delta and theta wave in prefrontal and frontal brain regions using SPSS version 24.0. A $p$-value of $\leq 0.05$ was considered statistically significant.

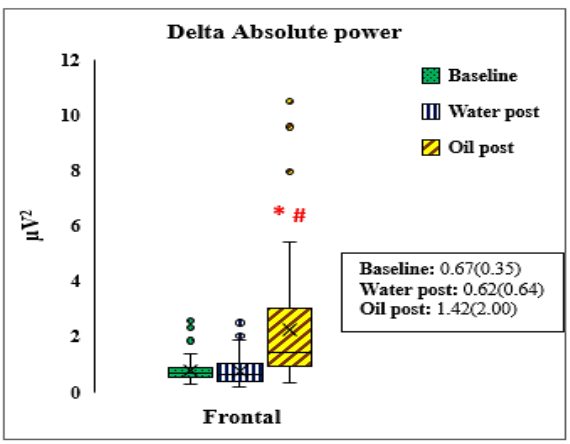
## RESULTS

Thirty women, all in good health, aged 25-38 years (average age 32.4 ± 2.50 years), and with BMI values ranging from 20.5 to 24.92 kg/m$^2$ (average BMI 23.35 ± 1.11 kg/m$^2$), were enrolled in this experiment. The demographic characteristics are outlined in Table 1. The examination of EEG data revealed significant increase in both the absolute ($p$=0.002) and relative power ($p$=0.000) of theta in the prefrontal region while comparing the post-exposure condition to the baseline recording. Additionally, significant elevation was noted in the absolute power of both delta ($p$=0.000) and theta ($p$=0.000) waves in the frontal region (Figure 1). These results were corroborated by comparing the recordings of post-control with those following exposure to LEO mist.

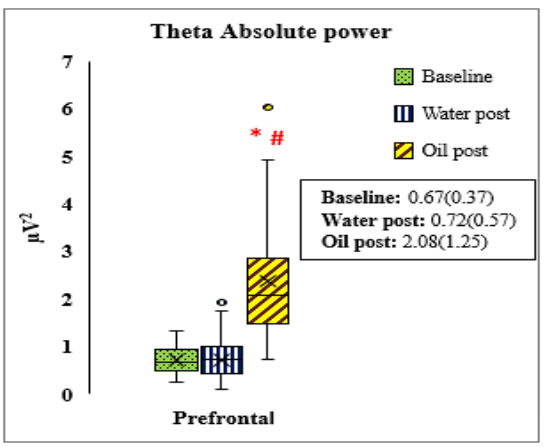
**Table 1: Demographic characteristics and clinical data of study subjects (N=30)**

| Parameters | Minimum | Maximum | Mean ± SD |
|---|---|---|---|
| **Age** (years) | 28 | 38 | 32.4 ± 2.50 |
| **BMI** (kg/m$^2$) | 20.50 | 24.92 | 23.35 ± 1.11 |
| **Pulse** (beats/min) | 64 | 88 | 77.33 ± 7.78 |
| **SBP** (mmHg) | 108 | 126 | 115.47 ± 5.48 |
| **DBP** (mmHg) | 64 | 84 | 74.47 ± 5.98 |
| **Smell test** (Bottle no.) | 9 | 11 | 10.3 ± 0.70 |
| **Handedness** (Score) | 60 | 100 | 77.33 ± 14.13 |

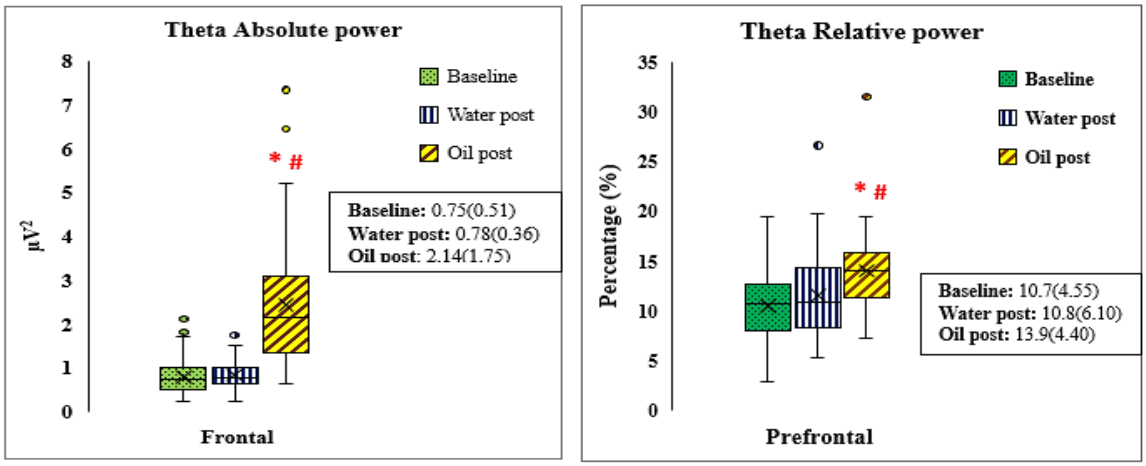
**BMI**- Body Mass Index; **SBP**- Systolic blood pressure; **DBP**- Diastolic blood pressure;
**N**- Total number of subjects.




(a)




(b)




(c) (d)

**Figure 1:** (a) Delta absolute power in frontal region; (b) Theta absolute power in prefrontal; (c) Theta absolute power in frontal and (d) Theta relative power in prefrontal region. *depicts significance when post-oil mist exposure compared to baseline; #depicts significance in comparison between post water and oil mist exposure. *p*-value ≤ 0.05 considered significant.

## DISCUSSION

Our research emphasizes the impact of scents on brain activity, particularly in high-amplitude, low-frequency brain wave patterns. Previous studies have shown that inhaling different aromatic agents can significantly influence brain function and physiological state by affecting the central nervous system. The prefrontal and frontal areas of the brain play crucial roles in various cognitive processes, including memory, reasoning, emotion, and management, collaborating with other brain regions and deep nuclei for effective execution[12]. Certain cortical regions exhibit dominant slow waves and rhythmic delta activity in individuals without brain abnormalities. Rhythmic delta activity in awake humans can indicate normal functioning neocortical circuits[6,13].Inhaling methyl eugenol and cannabis essential oil increased delta activity in anterior and posterior brain regions respectively, the former one paralleling our findings and suggesting sustained alertness similar to sleep deprivation[14]. Studies have also demonstrated increased theta power following inhalation of aromatic oils such as lavender, tangerine, and cannabis EO, contributing to overall relaxation and reduced anxiety, possibly involving the limbic system[8,12,14]. This relaxation is evident in practices like meditation and yoga, triggering the release of hormones like melatonin, serotonin, and cortisol[14]. Another study using a blend of lavender and bergamot oil observed increased theta power in anterior brain regions, echoing our results and indicating a state of internal relaxation, mental comfort, and subjective stability[15].

The swift onset of the effect suggests a direct and immediate impact of the olfactory stimulus on neural rhythms. Fragrant particles exert their effects by interacting with olfactory receptors, transmitting signals to various brain regions including the primary olfactory cortex, piriform cortex, amygdala and some deep nucleus. Once processed, this information is relayed to higher brain centers to regulate cognition, memory, emotion, and behavior. Additionally, besides stimulating the olfactory pathway, these chemical particles are absorbed through nasal and lung mucosa into systemic circulation to reach the central nervous system and influence brain functions[16,17]. According to GC/MS analysis, citral and geraniol are identified as the primary components of LEO. Citral,

acting as an agonist to both Gamma aminobutyric acid A ($GABA_A$) and 5-hydroxytryptamine 1A ($5\text{-}HT1_A$)receptors, has the potential to reduce anxiety levels in animals[18]. On the other hand, geraniol exhibits antidepressant effects by influencing the serotonergic system, specifically by potentiating $5\text{-}HT1_A$ receptor activity and enhancing the effects of serotonin in the central nervous system[19]. Furthermore, inhalation of LEO demonstrated a reduction in anxiety during induced anxiogenic situations in human subjects[20], while a separate study claimed deep relaxation state of mind [4] which mirrors our findings substantially.

## CONCLUSION

In summary, this study offers initial indications that exposure to the aroma of lemongrass oil may induce increased theta activity across the entire frontal region, coupled with a partial increase in delta power, providing a generalized state of relaxation and heightened background neural activity.

## LIMITATION

Limitations of this study include the absence of both sexes in the participant pool and the inability to administer the aroma over a longer duration and inclusion of participants from different age groups. Moreover, pathological cases were not taken into consideration.

## RECOMMENDATIONS

Further research should focus on investigating the mechanisms underlying the neural changes, as well as exploring high and low divisions within the band frequencies.

### *Implications:*

The application of olfactory stimulation on the functional state of the brain could open up new avenues in clinical research, particularly for early intervention in conditions such as depression, anxiety, and panic disorders.

## CONFLICT OF INTEREST

This author declares no conflict of interest.

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