Central Medical College Journal
Vol 7 No 2 July 2023
DOI: https://doi.org/10.3329/cemecj.v7i2.74418

Original Article

Fragrance and frequencies: EEG analysis of theta spectral edge frequency after olfactory stimulation by spearmint.

Sadia E[1], Ahmed R[2], Patwary MSI[3], Jahan I[4]

Abstract

Background: *Sense of smell plays a crucial role in emotions, memories, and cognitive processes. The interplay between olfaction and neural activity has intrigued researchers for decades. The signals pass through the olfactory bulb to emotional centers, impacting emotions and memory recall and influencing brain function beyond fragrance identification. Fragrant oils have gained modern attention for their potential to influence cognitive and emotional states. The oil of spearmint is celebrated for its refreshing and calming properties, has emerged as a significant contender in in this context.* ***Objectives:*** *To investigate real-time changes in theta wave Spectral Edge Frequencies (SEF) in response to spearmint fragrance, aiming to understand the dynamic interplay between fragrance and brainwave frequencies.* ***Materials and Methods:*** *Thirty healthy females were exposed to the fragrance of spearmint essential oil and their brain wave activities were monitored in five brain regions. The recordings were analyzed before and after smelling the fragrance. Wilcoxon Matched-pairs signed Rank test was considered for comparison.* ***Results:*** *Our findings suggest that the olfactory stimulation of spearmint did not exhibit significant influence on the SEF theta waves in any brain regions except in the parietal region. Only this region showed significant shift of theta SEF to a higher frequency after smelling the fragrance compared to baseline (p=0.04).* ***Conclusion:*** *The study revealed no noteworthy alterations in spectral edge frequencies of theta waves in brain regions linked to cognition, memory, or emotions. So, further exploration is recommended, especially in different demographic groups including other waves.*

Keywords: *Fragrance, spearmint, EEG, Spectral Edge Frequency.*

Introduction: The human sense of smell is a powerful gateway to emotions, memories, and cognitive processes, is often overlooked in comparison to other senses[1,2]. This special sense is emerging as a dynamic pathway capable of exerting profound influences on various aspects of brain function beyond its primary function of perceiving and identifying fragrances[3,4].

The olfactory pathway begins with the detection of odor molecules by olfactory receptors in the nasal epithelium. These receptors, part of the largest gene family in the mammalian genome, initiate a cascade of events that culminate in the transmission of signals to higher brain centers[3,5,6].The olfactory bulb, acting as the initial processing center, refines and organizes these signals before relaying them to regions such as the amygdala, hippocampus, and prefrontal cortex[7-11]. One of the remarkable aspects of the olfactory pathway is its direct and intimate connection to the limbic system, the brain's emotional hub. This direct linkage positions olfaction as a potent influencer of emotional states and memory recall. This unique ability of fragrances to evoke powerful emotions and trigger vivid memories, showcasing the olfactory pathway's ability to interface with and influence brain regions associated with these processes[3,12].

1. **Dr. Esaba Sadia,** *MBBS, MD, Lecturer, Department of Physiology, Ibrahim Medical College, Shegunbagicha, Dhaka.*
2. **Dr. Rezvi Ahmed**, *MBBS, Khwaja Yunus Ali Medical College, Enayetpur, Shirajganj.*
3. **Dr. Md. Shaiful Islam Patwary,** *MBBS, MD, Assistant Professor, Department of Physiology, Central Medical College, Cumilla.*
4. **Dr. Israt Jahan,** *MBBS, MD, Lecturer, Department of Physiology, Armed Forces Medical College, Dhaka Cantonment, Dhaka.*

Correspondence : **Dr. Esaba Sadia,** *MBBS, MD, Lecturer, Department of Physiology, Ibrahim Medical College, Shegunbagicha, Dhaka.Cell: +8801929168706; E-mail: esabasadia@gmail.com*

Received date: 22 January 2024
Accepted reviewed version date: 14 April 2024

Central Medical College Journal
Vol 7 No 2 July 2023
DOI: https://doi.org/10.3329/cemecj.v7i2.74418

Furthermore, olfactory stimulation, including exposure to specific fragrances such as essential oils like Lavender, Rosemary, Jasmine, mint oil, has been implicated in modulating cognitive functions[3,21,22,23]. Mint is the genus containing about 30 members including spearmint (Pudina), the distinctive aroma of which has been associated with relaxation, making it a prime candidate for understanding how olfactory stimulation can modulate neural activity.[12-14] The oil this plant is obtained through steam distillation of the leaves & flowering tops, capturing the concentrated aromatic compounds (carvone, 1-8, cineol, limonene) that contribute to its distinct fragrance and potential therapeutic benefits.Despite its historical use, the specific impact of mint oil on neural oscillations remains an intriguing and underexplored area of research[15-18]. This study seeks to bridge this gap by employing electroencephalography (EEG) to capture real-time changes in theta band spectral edge frequency (SEF) in response to olfactory stimulation with mint oil, thus enhancing our comprehension of fragrance-brain interactions.

In EEG studies SEF is a pivotal metricrepresenting the frequency below which a certain percentage of the power spectral density resides. Itholds the potential to elucidate the distribution of brainwave frequencies and their correlation with cognitive states.[19-20] Among different range of neural oscillations in the brain; theta wave represents the frequency ranging between 4-8 Hz, alpha wave 8-12 Hz and beta wave between 12-30 Hz[3,4]. Beta waves are usually observed to dominate when the brain is engaged in executing a task with highest concentration while with decreasing frequency the brain gets more relaxed and calmed.[3] Slower wavesthetais associated with deep relaxation, creativity, and a state of deep meditation andgenerally present during sleep[4]. By examining changes in the theta Peak Power to a higher frequency, authors have suggested deep relaxing effect of the spearmint aroma[4]. This study aimed to explore any changes in the SEF of theta wave after the fragrance administration and to add more scientific evidence in regards to the effect of spearmint on cognitive function of brain.

Materials and Methods

This self-control trial took place in the Physiology Department of Bangabandhu Sheikh Mujib Medical University (BSMMU) from March 2022 to February 2023. Ethical approval was obtained from the Institutional Review Board of BSMMU. Participants underwent carefully monitored sessions of olfactory stimulation using spearmint oil, during which EEG electrodes were accurately positioned to capture brainwave activity before and after the stimulation. The analysis focused on EEG spectral edge changes within the theta wave range induced by exposure to the aroma of mint oil.

Participants

Healthy adult female volunteers were recruited through poster advertisements on the BSMMU campus. The selection and recruitment process involved considering specific criteria,inclusion criteria: 1) 25-38 years old; 2) right-handed; exclusion criteria: 1)smoker; 2) alcoholic; 3) history of neurological disease or disorder of olfaction; 4) under any hormonal pill or drugs affecting Central Nervous System[21,22,23]; ultimately enrolling thirty participants.

Numerous studies have reported variations in brain wave activity based on handedness. Therefore, this study specifically enrolled individuals who are right-handed. The Edinburg Handedness Inventory scale (EHI) was utilized to assess handedness[22], and a screening test involving n-butyl alcohol was conducted to evaluate participants' normal olfactory function (mean score 10.3 ± 0.70)[21]. Additionally, personal health details, encompassing BMI, blood pressure, and heart rate, were documented. Prior to participating in the experiment, all participants provided informed written consent, and a preparatory manual was provided.

Results from earlier research indicated that the functioning of the nervous system could be influenced by the perceived pleasantness of an aroma. Hence, prior to commencing the experiment, participants provided ratings for the pleasantness of the scent using a 5-point Likert scale. Those who rated the aroma as pleasant within the range of 2 to 4 points were eligible to participate in the experiment[4].

Experimental Design

Initially, participants experienced a 'no fragrance' session, serving as the control session, within a regulated environment (temperature 23-25°C, dark

Received date: 22 January 2024
Accepted reviewed version date: 14 April 2024

room, humidity 40-50%). After this session, their neural activity was assessed using Quantitative EEG. Subsequently, following a designated interval, participants were subjected to the aroma of spearmint oil within the same controlled environment, and their neural activity was measured subsequently.

Procedure

Participants were comfortably seated in a soundproof room and equipped with 19 EEG electrodes according to the international 10-20 system for electrode placement. These 19 scalp electrodes were divided into five categories consisting of regions prefrontal (FP1, FP2); frontal (F7,F3,FZ,F4,F8); central (C3,CZ,C4); parietal (P3,PZ,P4); temporal (T3,T4,T5,T6) and occipital (O1,O2).[3,24] Then initial EEG measurements were taken in eye-closed state as a baseline for 120 seconds.

In the no fragrance session, they were exposed to mist of only water generated by an ultrasonic diffuserfor 20 minutes and post exposure EEG measurements were obtained in eye-closed state immediately after the session.

During thefragrance session, spearmint essential oil (EO) was diluted in a 1:1000 ratio with water and diffused into the room air as a mist using the ultrasonic aroma diffusers. Participants then inhaled the spearmint EO scent for a duration of 20 minutes. Following the exposure, EEG measurements were extended for an additional 120 seconds in the post-test phase.

Data Analysis

For each recording during the baseline and post-exposure phases, 60-second EEG waves were assessed in all 19 leads in five brain regions using specialized software (BrainTech 40+ Standard version 4.47a). This software calculated spectral edge frequencies for each specific band, including theta. The data were presented as median (interquartile range), and the Wilcoxon Matched-Pairs Signed Ranks Test was utilized to compare pre-exposure values with post-exposure valuesand also to compare between post water and post oil exposure values. This statistical analysis aimed to identify significant changes in theta spectral edge frequencies. A p-value of ≤ 0.05 was considered statistically significant.

Results

The study involved 30 women in good health, aged 25 to 38 years, with an average age of 32.4 ± 2.50 years. Their body mass index (BMI) ranged from 20.5 to 24.92 kg/m2, with an average BMI of 23.35 ± 1.11 kg/m2. Table I provides a summary of demographic information and smell test results. Analysis of the EEG data unveiled intriguing insights into the effects of mint oil olfactory stimulation on spectral edge changes within the theta wave band. No observable shifts were displayed in spectral edge frequencies after exposure to spearmint oil fragrance inthe brain regions except the parietal [Table II]. This region showed increased value of SEF theta after oil exposure compared to before (p = 0.04) which was also higher when compared to post-water values (p=.05).

Table I: **Personal health details of the participants (N=30)**

Parameters	Mean (SD)
Age (years)	32.4 (2.50)
BMI (kg/m^2)	23.35 (1.11)
Smell test score (Bottle no.)	10.3 (0.70)
Handedness (Score)	77.33 (14.13)

Data were expressed as mean (SD). Values in the parentheses indicate ranges; N- Total number of subjects; BMI – Body Mass Index.

Table II: Values of SEF of theta brain wave before and after inhalation of water mist and essential oil mist (N=30)

Brain area	Baseline	Water (Control)	Spearmint fragrance
Prefrontal	7.3(0.7)	7.3(.07)	7.3(0.5)
Frontal	7.3(0.5)	7.3(0.2)	7.5(0.8)
Central	7.5(0.2)	7.5(.02)	7.4(0.8)
Parietal	7.3(0.5)	7.3(.05)	7.5(0.2) *#
Temporal	7.4(0.5)	7.5(.05)	7.3(.08)
Occipital	7.5(0.5)	7.5(0.2)	7.5(0.5)

Data were expressed as Median (IQR).Statistical analysis was done by Wilcoxon Matched- pairs Signed Rank Test. N- Total number of subjects. * depicts comparison between before and after smelling the spearmint and # depicts comparison of values after spearmint to that of after the water mist session. *$p \leq 0.05$; # $p \leq 0.05$

Received date: 22 January 2024
Accepted reviewed version date: 14 April 2024

Discussion

By examining this interface between fragrance and frequencies, our primary objectives include unraveling the acute effects of minty fragrance on theta band dynamicsand discussing the broader implications for cognitive neuroscience and therapeutic applications. While the prefrontal and frontal brain areas concerned with the cognitive brain function, emotions and judgment, and the occipital region is related to vision [24]. Fragrance recognition is the function of temporal region to some extent where the parietal region deals with object identification[24]. Based on the analysis of spectral edge frequencies of theta waves following exposure to spearmint fragrance in this study, none of the brain regions associated withcognition, memory or emotions showed any significant alteration. While someprevious authors suggested changes in the arousal state of the brain after of spearmint fragrance inhalation[4,25,26], our findingsindicated no significant potential for influencing cognitive states of brain particularly related to relaxation.

Acknowledgments

We express our appreciation to all the individuals who devoted their time to participate in this study, and we also extend our thanks to the research personnel who contributed to the collection and analysis of data.

Conclusion

Through this study we aimed to answer the question regarding the relationship between the minty fragrance and frequencies within the theta wave and also to contribute to the growing body of knowledge surrounding the intricate interplay between olfaction and neural oscillations but this is not conclusive. So,further study is highly recommended including SEF of other waves to reach to a solid conclusion.

Conflict of interest: None

References

1. Kim SM, Park S, Hong JW, Jang EJ, Pak CH. Psychophysiological effects of orchid and rose fragrances on humans. HorticSci Tech 2016; 34(3):472-487

2. Shepherd GM. The human sense of smell: are we better than we think? PLoS biology. 2004 May;2(5): e146.

3. Sowndhararajan K, Kim S. Influence of fragrances on human psychophysiological activity: With special reference to human electroencephalographic response. Sci Pharm. 2016; 84(4):724-52.

4. Sadia E, Jahan I, Ferdousi S, Ahmed R.Aromatic riddles of the mind: Delving into theta peak power frequency alterations in quantitative EEG after olfactory stimulation with spearmintaroma. JMCWH. In press.

5. Gaillard I, Rouquier S, Giorgi D. Olfactory receptors. CMLS 2004;61(4):456- 469

6. Mackay-Sim A, Royet JP, UniversityBrisbane G. The olfactory system. Olfaction and the brain: window to the mind. 2006; 3-27.

7. Breer H. Sense of smell: recognition and transduction of olfactory signals. BiochemSoc Trans 2003; 31(1):113-116

8. Anderson AK, Christoff K, Stappen I, Panitz D, Ghahremani DG, Glover G, Gabrieli JD, Sobel N. Dissociated neural representations of intensity and valence in human olfaction. Nat Neurosci 2003; 6(2):196-202

9. De Araujo IE, Rolls ET, Velazco MI, Margot C, Cayeux I. Cognitive modulation of olfactory processing. Neuron 2005; 46(4):671-679

10. Benarroch EE. Olfactory system: functional organization and involvement in neuro degenerative disease. Neurol 2010; 75(12): 1104-1109

11. Lane G, Zhou G, Noto T, Zelano C. Assessment of direct knowledge of the human olfactory system. Exp Neurol 2020; 329:113304

12. Van Toller S. The application of EEG measurements to the study of sensory responses to odours. Trends in Food Sci Technol 1991; 2:173-175

Received date: 22 January 2024
Accepted reviewed version date: 14 April 2024

13. Telci I, Sahbaz NI, Yilmaz G, Tugay ME. Agronomical and chemical characterization of spearmint (Mentha spicata L.) originating in Turkey. Econ Bot 2004; 58(4):21-728

14. Patra NK, Kumar B. Woodhead Publishing. In Handbook of Herbs and Spices, Spearmint. 2006; p.502-519

15. Taneja SC, Chandra S. Handbook of herbs and spices 2012; Chapter 20, Mint; p.366-387

16. Elansary HO, Ashmawy NA. Essential oils of mint between benefits and hazards. JEOBP 2013; 16(4):429-438

17. Mahendran G, Verma SK, Rahman LU. The traditional uses, Phytochemistry and pharmacology of Spearmint (Mentha spicata L.): A review, J. Ethnopharmacol 2021; 278

18. Adli DE, Brahmi M, Ziani K, Brahmi K, Kahloula K, Slimani M. Chemical Composition, in vitro Antioxidant, Antimicrobial and Cytotoxic Activities of Mentha spicata Essential Oil: A Review. Phytothérapie 2022; 1-8

19. Davis PD, Kenny GNC. Basic Physics and Measurement in Anesthesia, 5 th ed. Elsevier Ltd, Chapter 15, Biological electrical potentials: Their display and recording 2003; p.189-207

20. Laman DM, Wieneke GH, van Duijn H, Veldhuizen RJ, van Huffelen AC. QEEG changes during carotid clamping in carotid endarterectomy: spectral edge frequency parameters and relative band power parameters. Journal of clinical neurophysiology. 2005 Aug 1;22(4):244-52.

21. Sayorwan W, Siripornpanich V, Piriyapuniaporn T, Hongratanaworakit T, Kochabhakdi N, Ruangrungsi N. The Effects of Lavender Oil Inhalation on Emotional States, Autonomic Nervous System, and Brain Electrical Activity. J Med Assoc Thai 2012; 95(4):598-606

22. Sayorwan W, Ruangrungsi N, Piriyapunyporn T, Hongratanaworakith T, Kotchabhakdi N, Siripornpanich V. Effects of Inhaled Rosemary Oil on Subjective Feelings and Activities of the Nervous System, Sci Pharm 2012; 81(2):531 – 542

23. Sayowan W, Siripornpanich V, Hongratana worakit T, Kotchabhakdi N, Ruangrungsi N. The effects of jasmine Oil inhalation on brain wave activies and emotions. J Health Res 2013; 27(2):73-7

24. Liu S, Wang L, Gao RX. Cognitive neuroscience and robotics: Advancements and future research directions. Robotics and Computer-Integrated Manufacturing. 2024 Feb 1;85:102610.

25. Martin GN. Human electroencephalographic (EEG) response to olfactory stimulation: Two experiments using the aroma of food. Int J Psychophysiol 1998; 30(3):287-302.

26. Masumoto Y, Morinushi T, Kawasaki H, Ogura T, Takigawa M. Effects of three principal constituents in chewing gum on electroencephalographic activity. PCN 1999; 53(1):17-23

Received date: 22 January 2024
Accepted reviewed version date: 14 April 2024