A Preliminary Study on Aromatheraphy as a Stress Buster Using EEG Signal Analysis

C.R. Hema and S. Revathi

Abstract--- *Stress is an inevitable and unavoidable component of life due to increasing complexities and competitiveness in living standards . It is obvious that reduction in stress levels would cause beneficial effects . Aromatherapy is a form of alternative medicine that uses essential oils for the purpose of altering a person's mind , mood , cognitive function or health . It provides essential oils extracted from aromatic plants for medical objectives . The purpose of this study was to investigate the effects of aromatherapy and inquiring its efficiency on reducing stress levels in adults . The EEG activity of a subject was analysed to show the effects of aromatherapy on the brain and its functions . In this paper EEG activity for alertness and mood was assessed from one subject . 30 minutes of aromatherapy was given using popular aroma oils namely lavender , rose essential, lemongrass and sandalwood . The results were studied using signal processing techniques to ascertain the effects of essential oils on stress , besides identify the best aromatherapy oil for stress relief .*

Keywords--- *EEG Signal, Stress, Stress Busters, Aromatheraphy, Essential Oils*

I. INTRODUCTION

THE consequences of a stressful lifestyle include myriad symptoms from depression to decreased function of the immune system [1]. It affects the brain particularly those areas involved in emotions and learning namely Amygdala , Hippocampus , Prefrontal Cortex & Limbic System [2] . At high levels , the hormones released during stress response , cortisol and in particular glucocorticoids , kill brain cells [3]. Acute stressors such as daily hassles and tasks , are commonplace [4]. Medical research reports that stress may be largely responsible for causing or at least promoting more serious disorders such as heart disease and allergies . Stress also overworks the adrenal glands. Repeated release of an overabundance of adrenaline from these glands eventually disrupts the delicate balance of brain chemistry and hormonal production [5] .

It has been theorized that individuals who are exposed to a large number of acute stressors on a daily basis are more at risk for the lasting detrimental outcomes associated with stress. Stressors may be of any type including physical, work , psychological , family and environmental stressors . Thus, identifying methods that reduce the effects of stress has been the focus of much research. Traditional stress-management programs have included a wide variety of techniques including skills training, coping exercises, and behavioural modification. Further identifying methods that are easily applied, easily learned, convenient, and inexpensive may help to increase utilization of stress management.

In the past few years so called alternative medicines including aromatherapy, have gained in popularity .The problem with these “alternative” methods is that there is very little empirical evidence to suggest the claims made about their effectiveness as therapies. Very few studies have been done to test the efficacy of aromatic extracts as anti-stress agents [4] . The study of oils on blood pressure and stress responses showed that inhalation aromatherapy was an effective intervention that caused decrease in blood pressure ($p < 0.05$) [5] . A study, published in the 2009 Journal of Agricultural and Food Chemistry, found certain fragrances alter gene activity and blood chemistry in ways that can reduce stress levels . Akio Nakamura of the Technical Research Center at the T. Hasegawa Co. in Kawasaki, Japan, says that people have inhaled the scent of certain plants since ancient times to help reduce stress, fight inflammation and depression and induce sleep [6] . Metamora et al , studied the effects of the lavender odorant on a Japanese version of Cox and Mackay’s stress adjective checklist for three groups of subjects. Analysis suggested that lavender odorants were associated with reduced mental stress [7]. Toda and Morimoto studied the effects of exposing students to airborne organic essential oil of lavender at 5 and 10min after an arithmetic task. Results showed that the levels of (CgA- cortisol and chromogranin A) that had been elevated at the end of the arithmetic task suggesting increased stress were statistically significantly lower 10min later [8] . In another study by Park et al, was conducted on a group of junior nursing students . A pretest and post-test were conducted to measure body symptoms, the level of anxiety , and the level of perceived stress . In the experimental group , aromas were given using an aroma lamp such as , lavender , peppermint , rosemary and Clary-Sage . In the control group , the treatment was not administered . As a result of administering aroma inhalation to nursing students , their physical symptoms decreased , their anxiety scores were low , and their perceived

C.R. Hema, Faculty of Engineering, Karpagam University, Coimbatore. E-mail:hemacr@karpagam.ac.in
S. Revathi, Faculty of Engineering, Karpagam University, Coimbatore. E-mail:hemacr@karpagam.ac.in

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stress scores were low , showing that aroma inhalation could be a very effective stress management method [9] . These investigations were in accordance with the present study .

Through the anecdotal proof offered using essential oils, historical use of certain oil and the limited scientific research already undertaken aromatheraphy in stress reduction is trenchant with the essential oils which have therapeutic properties those actively work to lower stress and has been used since time immemorial , thereby aromatheraphy was considered as an effective method for lowering stress levels in this study . The effects of aromatheraphy can be administered through brain wave fluctuations. Kimura et al examined the effects of odors on changes in EEG after a monotonous stress task known as the Uchida-Kraeppelin test [10] . Different odors can influence EEG activity and affect psychological mood [11] . Occupying this principle the study monitored the changes in brain waves over aromatheraphy using EEG . The brain wave is categorized into frequency bands based on the frequency range.

The four major brain waves are distinguished by their different frequency ranges : Alpha brainwave states (8-12Hz) are typically associated with contemplation , visualization , problem solving and accessing deeper levels of creativity . Theta brainwave state (4-8Hz) are even slower in frequency and represent a state of deep relaxation and meditation , enhanced creativity , stress relief , light sleep and dreaming . The Beta brainwave state (12-40 Hz) are associated with a heightened state of alertness and focused concentration . Delta brainwave state(0-4Hz) are the slowest in frequency and represent a state of deep dreamless sleep .

Studies that monitored brain activity through the use of an EEG have reported that Lavender decreases theta waves, an effect shown to represent relaxation [13] . Both lavender and rosemary essential oils were shown to reduce cortisol (The stress hormone) levels in a study of 22 healthy humans [14] . Sandalwood was found to provide relaxing and calming effect [15] .The effects of lavender and rosemary fragrances on electrical brain activity , mood states and math computations were investigated by Diego et al .The EEG results were interpreted as indicating increased drowsiness in the lavender group and increased alertness in the rosemary group [17]. Researchers found similar results (greater relaxation , less anxiety, increased mood) with the scents of lavender and lemon [12] . These investigations could be considered as the evidences for the aroma oils chosen to the present study .

In this paper EEG activity of the subject was analysed prior and after the aromatheraphy . Preprocessing has been done with EEG signals recorded during three states namely normal , stress and aromatheraphy . The EEG signals were examined using spectrogram that shows a time varying spectral representation . Amplitude fluctuations of the signals were also observed pertained to the experimental states . This study revealed a significant change on stress levels in adults and proved as an evidence suggesting aromatheraphy for stress reduction.

II. METHODOLOGY

In this experiment the EEG signal acquisition has been done from one subject.The subject was seated at ease in a noise free room . The signals were acquired in three conditions namely normal , stress in which subject was exposed to a mental arithmetic task and aromatheraphy for a short time period of 5 minutes separately . Each process is repeated for five sessions per trail . Spectrograms are used to analyze the frequency patterns of the data obtained . The amplitude of the signals were noted to determine the signal energy . The experimental phase of this study was aromatheraphy using lavendar , rose essential , lemongrass and sandalwood oils . These odors were chosen based upon past research indicating that they typically effect cognitively based task performance or mood in some way (either enhancing or degrading) [12] .

Following is the description of signal acquisition protocols .

1. State 1- Normal
2. The subject is requested to relax.The subjects's EEG activity is recorded for normal condition .
3. State 2- Stress

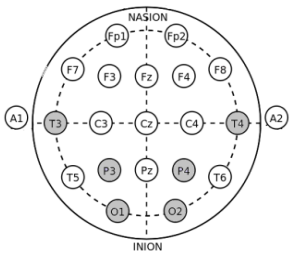

Figure1: Electrode Placement as per the 10-20 Intl Standards for Signal Acquisition

4. The subject is given a difficult mathematical problem to be solved . This is to note the stress created by this excercise .

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5. State 3- Aromatheraphy
6. Aromatheraphy is applied using the four essential oils namely lavendar , rose essential , lemongrass and sandalwood .

2.1 EEG Signal Pre Processing

The EEG activity is recorded for 30 minutes to observe the changes in activity in all the three conditions . This data can be considered as an addition of noises [16] . These artifacts are easily visible in time domain representation of signals . Thereby signal pre-processing is necessary to remove the artifacts encountered with the EEG signal . The type of pre-processing depends on the nature of the signal . In this experiment the EEG data were filtered using notch filter with a null frequency of 50 Hz to ensure perfect rejection of the strong power supply signals . The program was designed using MATLAB .

2.2 EEG Analysis

In this study the data were preprocessed and analysed using signal processing techniques . This technique consists of computing and observing spectrogram images from the data obtained in channel 3 and monitoring the change in amplitude of the EEG signal . The EEG signal is generally described in terms of its frequency bands namely alpha , beta , delta and theta . Spectrogram images obtained are observed in terms of the frequency bands with respective to time . It is computed with a 200-length Hamming window with an overlap of 5 samples . The amplitude of the EEG shows a great deal of inconsistency depending on external stimulation as well as internal mental states . Further the amplitude of signals obtained from all the three conditions has been analysed to show the signals strength with respective to the samples.

III. RESULTS AND DISCUSSIONS

The experimental results obtained from the subject in this study are depicted below as spectrogram images with a time period of 10 seconds and signal illustration . Alpha band for relaxed and calm state, beta band for consciousness , theta band for deep relaxation and delta band for deep dreamless sleep are the four frequency patterns observed from spectrograms . As a result aromatheraphy had noticeable decrease on stress levels in the subject from the 10th minute to 30th minute of the trail with all the four oils .The spectrogram images are shown from Fig 2 to Fig 7 . The EEG signals are illustrated from Fig 8 to Fig 13 . With respective to the spectrograms signals showed alpha patterns indicating focused concentration , contemplation and delta patterns for relaxed state , in the 10th and 15th minute of normal state in Fig 2 (a) , Fig 2 (b) . Decreased alpha and increased delta patterns were observed from 25th and 30th minute of the same trail signifying sleep state in Fig 2 (d) and Fig 2(e) . Similarly 20th minute of the normal state in Fig 2 (c) showed increased alpha patterns stating increased relaxation and less anxiety . From these observations it can be seen that the subject was found to be in a relaxed mood in the normal condition . Considering stress state the subject's brain activity was analysed when solving difficult mathematical problem . The subject was found to be stressed out to the entire trail.Fig 3 (c) and Fig 3 (d) showed increased alpha patterns and beta patterns from which it could be identified that the subject was more focused in problem solving in the 20th and 25th minute of the trail .Fig 3 (a) and Fig 3 (b) showed an awaken and conscious mood in the 10th and 15th minute of the trail with increased alpha band . A heightened state of alertness could be observed at this condition.

Spectrograms of aromatheraphy shown improved mood and relaxed state with all the four oils . The entire trail of aromatheraphy using lavender oil showed less anxiety mood with alpha and theta patterns . In specific from the 25th minute of trail , an ease off ,imaginary and dream state is observed in Fig 4 (d) with delta patterrns . Fig 4 (a) , Fig 4 (b) , Fig 4 (c) are seen with increased theta alpha and delta patterns in 10th , 15th and 25th minute of the trail indicating a drowsy and sleep state . In aromatheraphy using lemongrass oil increased theta pattern is observed in Fig 5 (a) , Fig 5 (b) in the 10th and 15th minute of the trail specifying a deep relaxed mood . Similarly Fig 5 (c) and Fig 5 (d) showed a calm state with theta and delta patterns in the 20th and 25th minute of the trail . Considering aromatheraphy with rose essential oil delta and increased theta patterns are observed in Fig 6 (a) , Fig 6 (b) in 10th and 15th minute of the trail stating a deep dreamless sleep state . Alpha and delta bands are observed in Fig 6 (c) , Fig 6 (d) and Fig 6 (e) in the 20th , 25th and 30th minute of the trail showing an less anxiety mood.Both lemongrass and rose oil had a substantial outcome at 20th and 10th minute of the trail for improving mood besides making the subject feel more relaxed and calm.The changes in EEG after inhalation of sandalwood oil had a significant transient effect in the 20th minute of the trail with increased delta and theta patterns in Fig 7 (c) . Fig 7 (a) of the experiment showed increased delta band stating a deep dreamless sleep.Similar frequency bands were also observed in the 30th minute of the trail in Fig 7 (e) . The specific observations from spectrograms for normal condition is seen in 25th minute of the trail .For stress condition better results are seen in 20th and 25th minute of the trail . Aromatheraphy using lavender oil and lemongrass showed specific improvement of mood in 10 and 20th minute of the trail . For aromatheraphy using sandalwood oil the specific observance is seen in the 15th minute of the trail as earlier. Analysis suggested that perceived stress scores were low with roseoil and sandalwood odorants compared to others from the 10th &15th minute of the trail.Drastic changes are seen to the entire sessions in the

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observed patterns of aromatheraphy using all the four oils compared to normal and stressed condition.With respective to signal illustration the energy of signal is administered over amplitude and number of samples.The measurement of amplitude in the present study is microvolts(μv).In general alpha waves has low amplitude of 50 μv. Considering normal condition Fig 8 (a) and Fig 8 (b) showed the signal power between 0 to 50 μv representating state of peacefulness in the 10^{th} and 15^{th} minute of the trail .Similarly Fig 8 (c) , Fig 8(d) and Fig 8 (e) showed amplitude between 0 to 50 μv stating mood with focused concentration and relaxation till the 30^{th} minute of the trail.

The amplitude of beta wave is less than 50 μv.These are the waves with lowest amplitude and high frequency.Beta power is observed during stressed state.In the figures elucidated for stress mood the amplitude is between -300 to 300 μv that showed an awaken state with more concentration in Fig 9 (c) , Fig 9 (d) and Fig 9 (e) from the 10^{th} minute to the 30^{th} minute of the trail . Similarly in Fig 9 (a) the amplitude is between 0 to -200 μv and in Fig 9 (b) its between -100 to 100 μv . Theta waves are those with low medium amplitude between 50 to 100 μv showing a light sleep state. Delta waves are those with high amplitude between 100 to 200 μv signifying a deep sleep state.In aromatheraphy using lavender oil Fig 10 (a) , Fig 10 (b) , Fig 10 (d) , Fig 10 (e) showed signal power between -200 to 200 μv with delta power in 10^{th} , 15^{th} , 25^{th} and 30^{th} minute of the trail specifying calm state . In aromatheraphy using lemongrass delta power is clearly observed in Fig 11 (c) where the amplitude is between -200 to 300 μv.Fig 11 (a) and Fig 11 (d) showed theta power with amplitude of -100 to 100 μv in the 10^{th} and 25^{th} minute of the trail .Similarly the figures illustrated for rose oil shows amplitude between -150 to 100 μv that represents theta power in Fig 12 (a) ,Fig 12 (b) , Fig 12 (c), Fig 12 (d) ,Fig 12 (e) in 10^{th} ,15^{th} , 20^{th} , 25^{th} and 30^{th} minute of the signal . Aromatheraphy with sandalwood oil has its amplitude between 0 to 100 μv throughout the trail . It could be observed in Fig 13 (a) , Fig 13 (b) , Fig 13 (c) , Fig 13 (d) ,Fig 13 (e) , from the 10^{th} minute to the 30^{th} minute of the trail with theta and delta power . All these observations of lemongrass , rose oil and sandalwood showed a deep relaxed state , calm mind and a dreamless sleep state with the signals .

Thus analysing the results obtained with spectrogram images computed for 10 seconds and signal illustration in this preliminary study on aromatheraphy as a stress buster using EEG analysis , determined that aromatheraphy can be considered as a stress buster . Though aromatheraphy inhalation using the four oils showed significant differences throughout the trail, compared to the others roseoil and sandalwood received lower stress scores at the earliest and could be evident in showing aromatheraphy as an effective stress buster.

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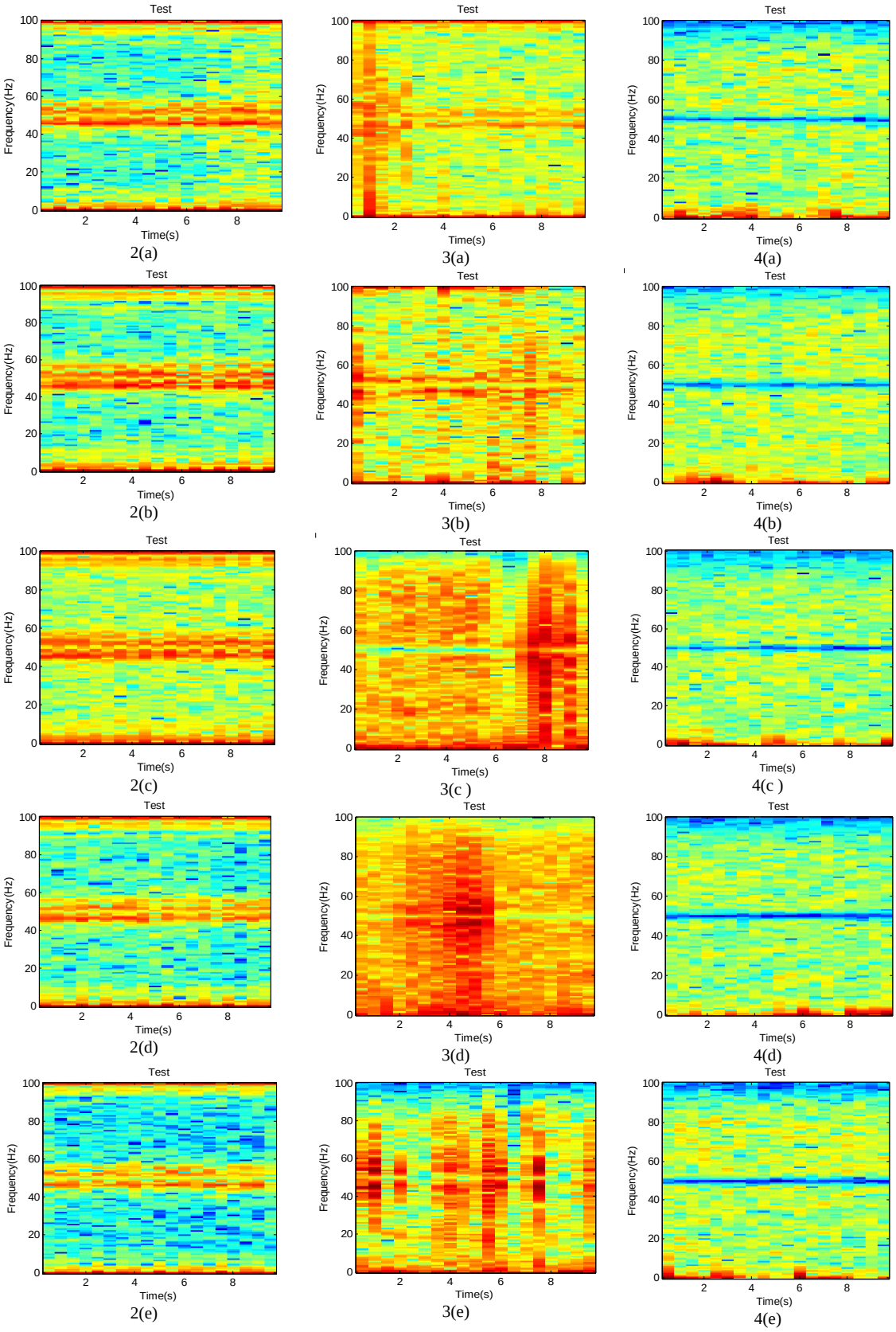

Figure 2: Spectrogram Images of Normal State at (a) 10th Minute (b)15th Minute (c)20th Minute (d)25th Minute (e)30th Minute
Figure 3: Spectrogram Images of Stress State at (a) 10th Minute (b)15th Minute (c)20th Minute (d)25th Minute (e)30th Minute
Figure 4: Spectrogram Images of Aromatheraphy using Lavender oil at (a) 10th Minute (b)15th Minute (c)20th Minute (d)25th Minute (e)30th Minute

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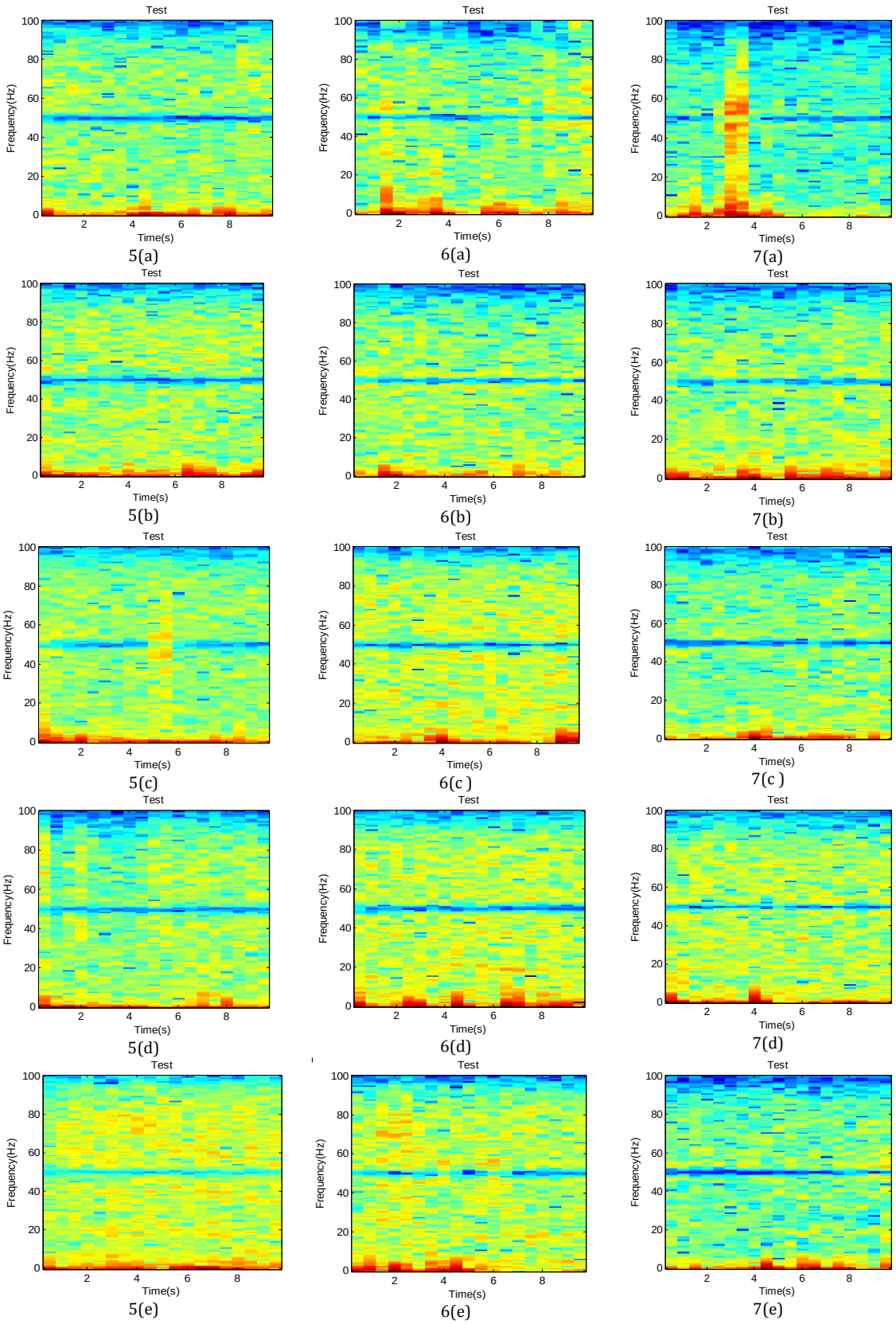

Fig 5 . Spectrogram Images of Aromatheraphy using Lemongrass Oil at (a) 10th Minute (b)15th Minute (c) 20th Minute (d) 25th Minute (e) 30th Minute

Fig 6 . Spectrogram Image of Aromatheraphy using Rose Essential oil at (a) 10th Minute (b)15th Minute (c) 20th Minute (d) 25th Minute (e) 30th Minute

Fig 7. Spectrogram Images of Aromatheraphy using Sandalwood oil at (a) 10th Minute (b)15th Minute (c) 20th Minute (d) 25th Minute (e) 30th Minute

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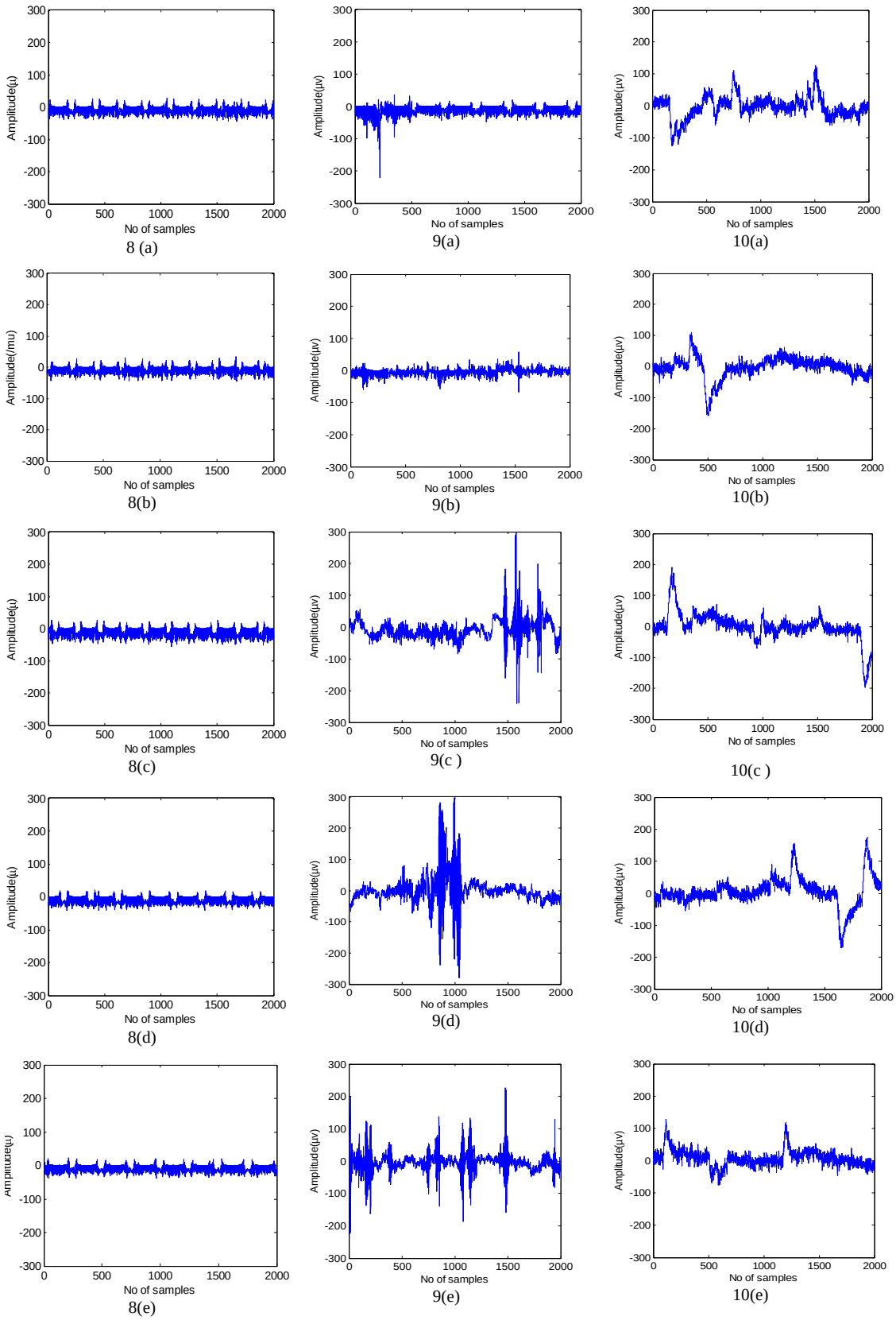

Fig 8. EEG signal of a Subject for Normal State at (a) 10th Minute (b)15th Minute (c) 20th Minute (d) 25th Minute (e) 30th Minute
Fig 9. EEG signal of a Subject for Stress State at (a) 10th Minute (b)15th Minute (c) 20th Minute (d) 25th Minute (e) 30th Minute
Fig 10. EEG signal of a Subject for Aromatheraphy using Lavender Oil at (a) 10th Minute (b)15th Minute (c) 20th Minute (d) 25th Minute (e) 30th Minute

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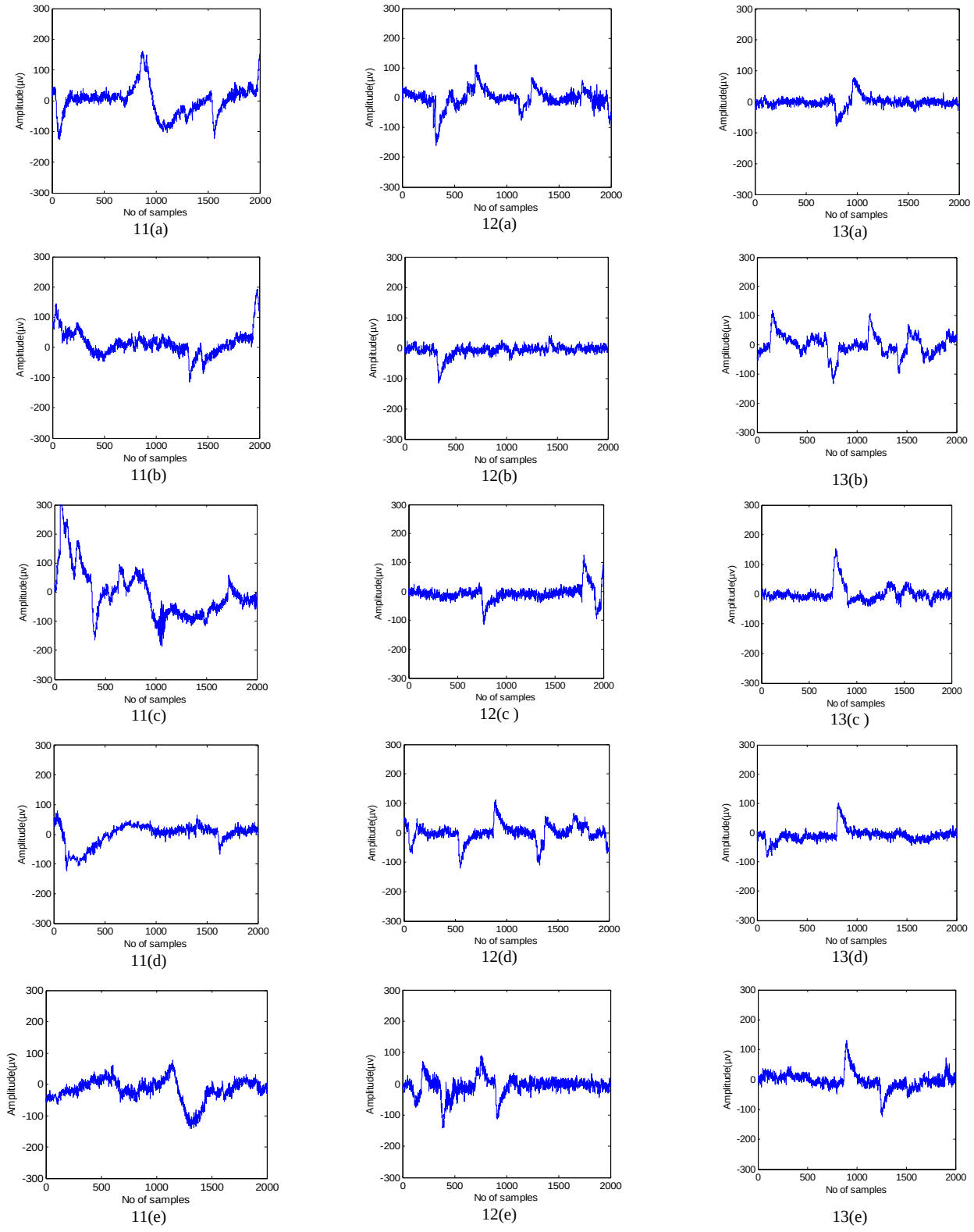

Fig 11. EEG Signal of a Subject for Aromatheraphy using Lemongrass Oil at (a) 10th Minute (b)15th Minute (c) 20th Minute (d) 25th Minute (e) 30th Minute

Fig 12. EEG Signal of a Subject for Aromatheraphy Using Rose Essential oil at (a) 10th Minute (b)15th Minute (c) 20th Minute (d) 25th Minute (e) 30th Minute

Fig 13. EEG Signal of a Subject for Aromatheraphy using Sandalwood oil at (a) 10th Minute (b)15th Minute (c) 20th Minute (d) 25th Minute (e) 30th Minute

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IV. CONCLUSION

This paper presents an analysis using EEG signals to show the effects of aromatheraphy as a stress buster . The brain state is analysed for different states , such as normal state , stressed state , and its state after aromatheraphy . Four aromatheraphy oils were used in this study namely lavendar , rose , lemongrass and sandalwood . Study shows that there is a significant reduction in stress levels due to aromatheraphy . Stress levels are seen to reduce after ten minutes of aromatheraphy usage.Rose oil and sandalwood are observed to be better aromas for reducing stress levels . Preliminary study on aromatheraphy as a stress buster using EEG signal analysis results show that aromatheraphy can be used as an effective stress buster . However more investigation is required on more number of subjects and with more ways of applying the aroma oils . Our future work will focus on other aroma oils and on varied subjects.

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