PROJECT NO. - 28

Study of Electrical Activity of Human Brain using Natural Scenes as Intervention

A PROJECT REPORT

Submitted in partial fulfillment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

in

ELECTRICAL ENGINEERING

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April, 2016

CANDIDATE'S DECLARATION

We hereby certify that the work which is presented in this project entitled "**Study of Electrical Activity of Human Brain using Natural Scenes as Intervention**" in the partial fulfillment for the award of the degree of Bachelor of Technology (Electrical) submitted to the Department of Electrical Engineering .I.I.T. Roorkee, is an authentic record of our own work carried out during the period from Jan'2016 to Apr'2016 under the guidance of **Dr. Vinod Kumar,** Professor, Department of Electrical Engineering, I.I.T. Roorkee.

The matter embodied in this project report to the best of our knowledge has not been submitted for the award of any other degree elsewhere.

April 19, 2016

Lilly Kumari Manpreet Singh

This is to certify that the above declaration is true to my knowledge.

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ACKNOWLEDGEMENT

We would like to give our sincere thanks to Dr. Vinod Kumar, Professor, Department of Electrical Engineering, IIT Roorkee who guided and motivated us to work professionally maintaining highest level of ethics throughout the duration of the project. Without his constant monitoring and guidance, it would have been impossible to achieve results. We also thank Mr. Gaurav, Research Scholar, EED who helped us in understanding the B-Alert BioPAC setup & Acqknowledge software and students who participated in the study.

ABSTRACT

The stresses and strain of urban environment are widely acknowledged. Many theories suggest urban natural environment can provide setting for restorative experience. This project aims to study the effect of such intervention in the form of visual & audio stimuli on the human brain. The effect is studied in the form of variations in brain waves, EEG band ratios and physiological/cognitive activity indices. The subjects are given the stimuli in the form of 360° videos played on Virtual Reality (VR) Headset:-

(i) Natural scenes (ii) Non-natural scenes

Using the B-Alert wireless system, the EEG (electroencephalography) data is collected for each subject. The variations in the electrical activity of brain while viewing the two videos are measured in the form of changes in spectral power density of brain waves and several EEG band ratios. Alpha band activities decreased in both kind of scenes but decreased more in case of non natural scenes. Similarly beta activity decreased for both the cases but decrease was more in case of non-natural scenes for P3,P4,POz,Fz,Cz positions while beta decreased more for natural scenes for F3,F4,C3,C4 positions.

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1. INTRODUCTION

With the advent of the digital world, our world has become more consumed by appliances, robots, machines etc. Most of the time people in cities remain indoors, mostly in front of TV, computers and their contact from nature is missing somewhere. Richard Louv coined a phrase “Nature Deficit Disorder” and stated this to be cause of wide range of behavioral disorders. Now with modern type of lifestyle, cardiovascular diseases, depression and modern ailments like neurological disorders are increasing and are linked to lack of exposure to nature. Therefore it is important to understand how viewing nature can affect the psychology.

Edward O Wilson introduced a hypothesis known as “biophilia hypothesis” which states that there is an instinctive bond between human beings and nature/living beings. This hypothesis, among many things, tries to explain why we keep flowers and plants in and around our homes/workplace. Trees and flowers, landscaped areas, and even very small parks provide opportunities for mind-filling moments. They provide patterns that humans attend to effortlessly and, in the process, they permit moments of recovery from the strains of the day.

Another theory developed by Rachel and Stephen Kaplan, Attention Restoration Theory states that people can concentrate better after spending time in nature, or even looking at scenes of nature.

A study (Ulrich 1979a) shows that the nature views significantly improve the emotional states of stressed individuals, whereas exposure to the urban scenes tend to work against emotional well-being. It is also shown that viewing nature increases positive mood reduces stress and decrease blood pressure. The results in the study suggest that the importance of visual contacts with nature extend beyond aesthetic benefits, and include a range of benefits in terms of psychological well-being.

EEG is one such tool which can help us understand psychology and physiology of brain. EEG is highly complex and combines five different frequency waveforms, namely δ (delta), θ (theta), β (beta), α (alpha) and γ (gamma) waves. The amplitude of the brain waves is approximately in the range of 10 μV to 250 μV and the frequency varies between 0.5 Hz and 100 Hz. The decreased alpha (8-13 Hz) activity is associated with increased cortical EEG activity in the cortical region and relative contributions of cerebral hemispheres can be inferred by evaluating the relative power of the alpha & beta activity.

The purpose of our study is to gather effective insights from the EEG data collected from the subjects and to evaluate the changes in power spectral densities corresponding to alpha & beta waves as well as variations of different EEG band ratios in the form of different physiological indices. Also, since the decrease in power spectral density (PSD) of alpha is associated with increased activity in cortical region, we have built a model which predicts the decrease in PSD of Alpha waves (after being virtually in a natural environment) as a function of Alpha waves PSD value during blank

relaxed modes & Alpha waves value while being virtually in an urban space. So, the model reflects the percentage by which a person’s cortical activity increases while being in a natural space.

2. TERMINOLOGY

2.1 Electroencephalography (EEG)

Electroencephalography (EEG) is a non-invasive method to detect and record electrical activity of brain along the scalp. EEG is most often used to diagnose epilepsy, which causes abnormalities in EEG readings. It is also used to diagnose sleep disorders, coma, encephalopathies, and brain death. EEG used to be a first-line method of diagnosis for tumors, stroke and other focal brain disorders, but this use has decreased with the advent of high-resolution anatomical imaging techniques such as magnetic resonance imaging (MRI) and computed tomography (CT). Despite limited spatial resolution, EEG continues to be a valuable tool for research and diagnosis, especially when millisecond-range temporal resolution (not possible with CT or MRI) is required.

2.2 Virtual Reality

Virtual Reality (VR), which can be referred to as immersive multimedia or computer-simulated life, replicates an environment that simulates physical presence in places in the real world or imagined worlds and lets the user interact in that world. Virtual reality artificially creates sensory experiences, which can include sight, hearing, touch, and smell.

2.3 Hardware Used

1. Sony HMZ T1
   Virtual reality headset by Sony for immersive experience and viewing 360 degree videos.

2. Be-alert(Wireless EEG monitoring device)
   Be-alert is EEG data acquisition device with 9 channels and 256 Hz sampling rate.

2.4 Software Used

- B-Alert / Acqknowledge
  It is a tool which records, filters the noise and filters the data into specific bandwidths for alpha, beta, delta and theta. It can also quantify the activity in each band.

- VR Player
  VR player is an experimental virtual reality media player for Head-Mounted display devices like Oculus Rift.

- R-Studio

  It is a software package very similar to MATLAB which is used by statisticians for data analysis. In our project, we have used R-Studio to sample out the EEG data obtained from the fifteen subjects and perform the required mathematics (calculating averages & deviations etc) on the sampled data.

  We also used it for building a predictive model using stepwise regression. For that, we have used the MASS library. The model predicts the decrease in PSD of Alpha waves (after being virtually in a natural environment) as a function of Alpha waves PSD value during blank relaxed modes & Alpha waves value while being virtually in an urban space.

- R-Shiny

  It is a web application framework for R. It makes it incredibly easy to build interactive web applications with R. Automatic "reactive" binding between inputs and outputs and extensive pre-built widgets make it possible to build beautiful, responsive, and powerful applications with minimal effort. We used it make an UI (user-interface) to observe changes in PSDs of Alpha & Beta waves and different indices mentioned in next section as shown in Figure 2.1 & Figure 2.2.

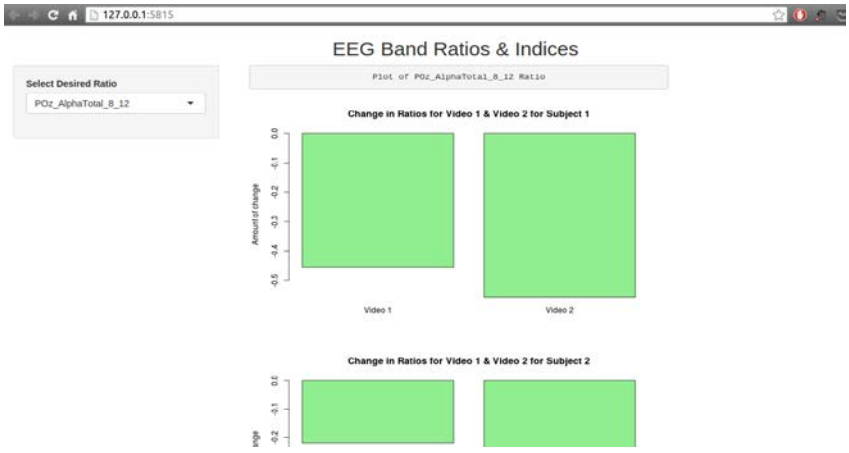


Figure 2.1: A screenshot of developed User Interface

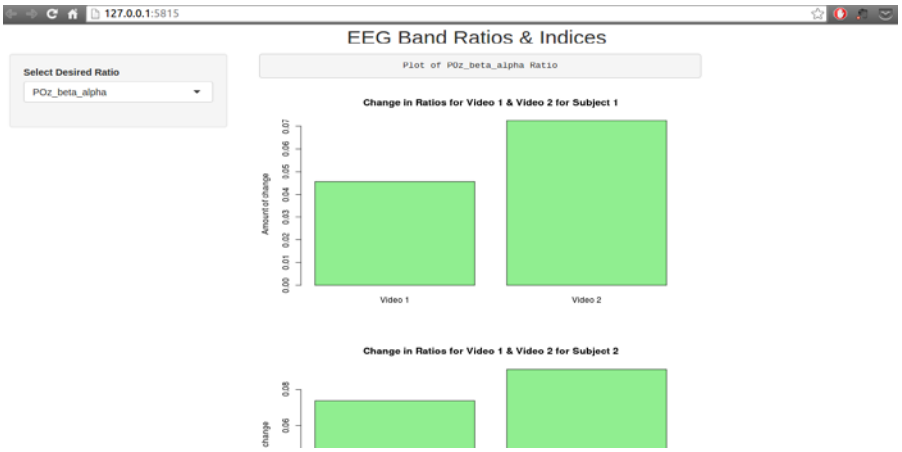


Figure 2.2 : A screenshot of developed User Interface

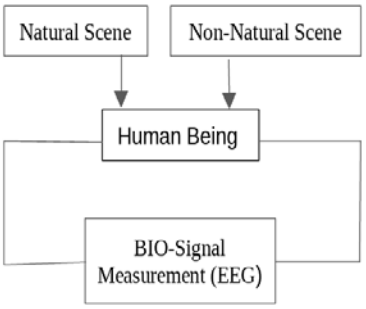


Figure 3.1: Experimental Schematic

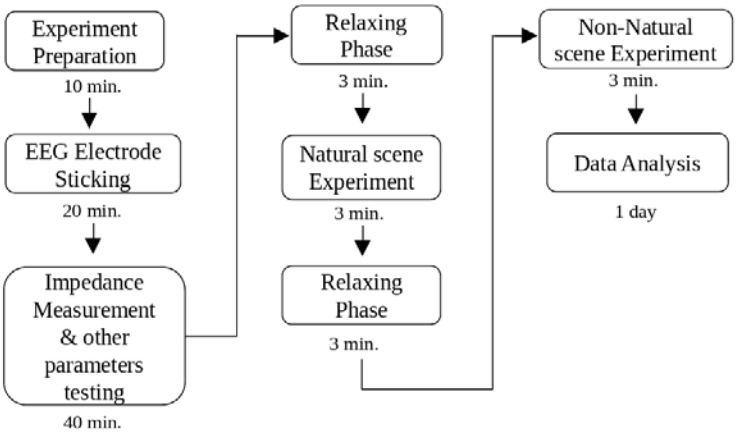


Figure 3.2: Experimental Procedure

3.1 Experimental Design

The study involved total 15 students of age range 21-23, whose height and weight were in the following range:- (5 ft 3 inches-6 ft) and (43-95 kgs) fully rested with sound health. The subjects were allowed to relax before the experiment. They were asked to minimize the blinking and motion during the experiment in order to avoid motion artifacts. During the experiment, lights were turned off so that the external lights can't interfere.

The EEG measurement process consisted of creating a definition file for each subject. It involved impedance calculations corresponding to each scalp electrode and acquisition of baseline data to create the individualized EEG profiles required for the B-Alert cognitive state metrics (B-Alert model and Workload models). The impedance values came very high when measured for female subjects because of high hair density. So, the entire procedure was repeated on male subjects only.

Once the electrodes were placed (for EEG measurement), subjects were made to wear VR (Virtual Reality) headset as shown in Figure 3.3. There were two types of 360° videos shown - one involving natural scenes (forest, underwater) and other involving urban scenes (apartment view). Subjects were shown black screen for 3 minutes and then a video for 3 minutes again followed by black screen and another video as shown in Figure 3.4 & 3.5 and Figure 3.6 & 3.7. Subjects were allowed to view the scene freely using a mouse because otherwise there was a chance of introduction of too much motion artifact. Number of videos were selected so that in total it would take 10-15 minutes as VR may cause uneasiness to some people on prolonged use. Continuous EEG was recorded during those 10-15 minutes.

Figure 3.3: EEG Recording at the Bio-Medical Instrumentation Lab

Figure 3.4: A scene from underwater vegetation (Natural) video

Figure 3.5: A scene from underwater vegetation (Natural) video

Figure 3.6: A scene from apartment (Non-natural) video

Figure 3.7: A scene from apartment (Non-natural) video

3.2 EEG Measurement

EEG was recorded using B-ALERT X10 biopac. B-ALERT X10 provides an integrated approach for wireless acquisition and recording of electroencephalographic (EEG) signals. The B-ALERT X10 acquires nine channels of monopolar EEG recordings with a linked mastoid reference. The B-ALERT X10 consists of: Head and Host Units for bi-directional transmission of digitized physiological signals, a Neoprene Strap, and a Sensor Strip with EEG sensor sites in the frontal (Fz, F3 and F4), central (Cz, C3 and C4) and parietal-occipital (POz, P3, and P4) regions as shown in Figure 3.8. The Sensor Headset collects physiological signals from the sensors placed on the user sampling at 256 Hz.

The impedance was maintained below 50kΩ throughout the experiment as shown in Figure 3.9. Then baselines for B-Alert classifications were acquired by the setup. This created the individualized EEG profiles required for the B-Alert cognitive state metrics (B-Alert model and Workload models). The "Baseline" AMP (Alertness & Memory Profiler) obtained 5 minutes each of a 3-choice psychomotor vigilance task (3CVT), eyes open (EO), and eyes closed (EC). The subjects had to complete at least three neurocognitive tests :-

- Three-Choice Vigilance Task (3CVT)
- Eyes Open – (EO)
- Eyes Closed – (EC)

Figure 3.8: The complete B-Alert X-10 setup

All the definition files created after the tests were saved in the subject's folder and the procedure shown in Figure 3.1 & Figure 3.2 was carried out on each subject.

For generating B-Alert's classifications for each second of a given .ebs file (one corresponding to each subject), PSDs (1-40Hz) for the referential channels (POz, Fz, Cz, C3, C4, F3, F4, P3, P4 as shown in Figure 3.10 were computed. PSDs were computed for each second of a given session without the Kaiser windowing procedure. Relative power values (_rel) were derived by subtracting the logged power of the individual Hz bin from the summed logged power for the EEG band (1 – 40 Hz) for that channel.

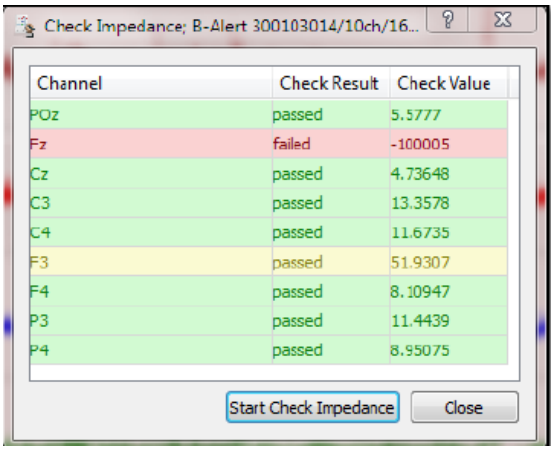


Figure 3.9:Impedance calculation by B-Alert Setup

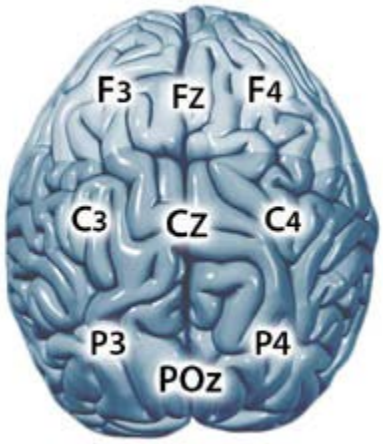


Figure 3.10: B-Alert X-10 Electrode Sites (showing all 9 channels)

The PSD (Power Spectral Density) for all 9 channels (POz, Fz, Cz, C3, C4, F3, F4, P3, P4) were calculated corresponding to following bandwidths:-

1. Delta_1_2 - Delta Bandwidth summed from Hz bins 1-2
2. ThetaSlow_3_5 - Theta-Slow Bandwidth summed from Hz bins 3-5
3. ThetaFast_5_7 - Theta-Fast Bandwidth summed from Hz bins 5-7
4. ThetaTotal_3_7 - Theta-Total Bandwidth summed from Hz bins 3-7
5. AlphaSlow_8_10 - Alpha-Slow Bandwidth summed from Hz bins 8-10
6. AlphaFast_10_12 - Alpha-Fast Bandwidth summed from Hz bins 10-12
7. AlphaTotal_8_12 - Alpha-Fast Bandwidth summed from Hz bins 8-12
8. Beta_13_29 - Beta Bandwidth summed from Hz bins 13-29
9. Sigma_13_29 - Sigma Bandwidth summed from Hz bins 13-29

Following mean PSD values were also calculated:-

1. **ThetaOverall_3_7** - Mean PSD across ALL 9 referential channels (POz, Fz, Cz, C3, C4, F3, F4, P3, P4) for Theta-Total Bandwidth (not relative PSD) summed from Hz bins 3-7 (without Kaiser windowing)
2. **AlphaOverall_8_12** - Mean PSD across ALL 9 referential channels (POz, Fz, Cz, C3, C4, F3, F4, P3, P4) for Alpha Bandwidth (not relative PSD) summed from Hz bins 8-12 (without Kaiser windowing)
3. **BetaOverall_13_29** - Mean PSD across ALL 9 referential channels (POz, Fz, Cz, C3, C4, F3, F4, P3, P4) for Beta Bandwidth (not relative PSD) summed from Hz bins 13-29 (without Kaiser windowing)
4. **SigmaOverall_30_40** - Mean PSD across ALL 9 referential channels (POz, Fz, Cz, C3, C4, F3, F4, P3, P4) for Sigma Bandwidth (not relative PSD) summed from Hz bins 30-40 (without Kaiser windowing)

For each subject, we divided the obtained values of PSDs corresponding to the combination of 9 channels (POz, Fz, Cz, C3, C4, F3, F4, P3, P4) and before mentioned 9 bandwidths into following four sections:-

- Blank Screen before Natural Video (~3 mins)
- Underwater Vegetation (Natural) Video (~3 mins)
- Blank Screen before Non-Natural Video (~ 3 mins)
- 3-D Apartment (Non-Natural) Video (~3 mins)

For each of the four sections, we eliminated those readings which had captured motion artifacts. After filtering and cleaning the EEG data having PSD variation, we averaged the value of PSD corresponding to all the 81 possible combinations of 9 channels & 9 bandwidths.

For benchmarking our model, we used the “Blank Screen” duration video before the natural & non-natural videos as the reference for the channel bandwidth value. So, in order to obtain the variation in PSDs of different brain waves because of the subject watching natural (or non-natural) videos, we took a difference between the PSDs values recorded corresponding to Natural (or Non-Natural) video and the PSDs values recorded during the blank screen presented before that video.

Since alpha waves (8-12 Hz) are needed as the bridge to the lower frequencies of the subconscious (theta), if we want to remember the content of our dreams or our meditation, or if we want to retrieve information from our subconscious. For this reason alpha is especially important. Also, Beta waves (13-29 Hz) are the brainwaves of our "normal" waking consciousness, of our outward attention, of logical, conscious and analytical thinking. High frequency beta ("splayed beta") is seen with restlessness, stress, anxiety, panic or while our inner critic or commentator is active. Low frequency brain waves represent the subconscious & the unconscious state. So, in our study, we aimed at studying the variations in PSDs of alpha & beta waves as a result of the subject watching the natural & non-natural videos.

Apart from the alpha & beta waves PSD variation, different EEG ratios have been used in this study to investigate cognitive performances in terms of physiological parameters as shown in Table 3.1.

EEG Band Ratios	Activity/Correlation
α/θ	Performance enhancement index or "wellbeing"
β/α	Arousal index
β/(α + θ)	Cognitive performance and attentional resource index
β/θ	Neural activity
δ/θ	Synchronization
α/β	Desynchronization
(α + θ)/β	Vigilance index

Table 3.1 - EEG band ratios and their physiological/cognitive activity index interpretation

For studying the variation in PSDs of alpha & beta waves and different indices mentioned earlier, we averaged the changes (variation) occurring corresponding to all the 15 subjects.

3.3 Predictive Modelling

For building the predictive model, we used the *AlphaOverall_8_12* (mean PSD averaged across all the 9 channels) values averaged over the three sessions:-

- Blank Screen before Natural Video (~3 mins) - *B1_AlphaOverall_8_12*
- Blank Screen before Non-Natural Video (~ 3 mins) - *B2_AlphaOverall_8_12*
- 3-D Apartment (Non-Natural) Video (~3 mins) - *V2_AlphaOverall_8_12*

to predict the % change in decrease of PSD of Alpha waves when the subject is in a natural environment.

model = lm(Percent_decrease_nature ~ B1_AlphaOverall_8_12 + B2_AlphaOverall_8_12 + V2_AlphaOverall_8_12, data=sample[1:15,], model=TRUE)

The Spearman Correlation Coefficient (S) between the observed values and predicted values turned out to be greater than the Pearson Correlation Coefficient. This implied that the relationship is monotonic and not linear. So, we then fitted a logarithmic model on our dependent variable i.e. % decrease in PSD of alpha waves after being in a natural landscape.

model = lm(log(Percent_decrease_nature) ~ B1_AlphaOverall_8_12 + B2_AlphaOverall_8_12 + V2_AlphaOverall_8_12, data=data[1:15,], model=TRUE

4. RESULTS

The Power Spectral Density of alpha waves corresponding to Natural Video decrease with respect to that during blank screen. Even in case of Non-natural video, they decrease with respect to the blank screen presented before the 3D apartment video. But, the amount of decrease is more in case of the Urban (Non-Natural) video as compared to the underwater vegetation (Natural) video as shown in figure 4.1.

The Power Spectral Density of beta waves corresponding to Natural Video decrease with respect to that during blank screen. Even in case of Non-natural video, they decrease with respect to the blank screen presented before the 3D apartment video. But, the amount of decrease is more in case of the Urban (Non-Natural) video as compared to the underwater vegetation (Natural) video as shown in figure 4.2.

The *AlphaOverall_8_12* which is the mean PSD across ALL 9 referential channels (POz, Fz, Cz, C3, C4, F3, F4, P3, P4) for Alpha Bandwidth (not relative PSD) summed from Hz bins 8-12 also shows a decrease in both natural and non-natural videos with more decrease corresponding to the Non-natural video as shown in figure 4.3.

The *BetaOverall_13_29* which is the mean PSD across ALL 9 referential channels (POz, Fz, Cz, C3, C4, F3, F4, P3, P4) for Beta Bandwidth (not relative PSD) summed from Hz bins 13-29 also shows a decrease in both natural and non-natural videos with more decrease corresponding to the Non-natural video as shown in figure 4.4.

The performance enhancement index which is ratio between *alpha* and *theta* waves shows a relative decrease with respect to the blank screen readings as shown in figure 4.5. But, the decrease is more in case of the subject viewing the Urban Apartment (Non-Natural) video.

The arousal index which is ratio between *beta* and *alpha* waves shows a relative increase with respect to the blank screen readings as shown in figure 4.6. But, the increase is more in case of the subject viewing the Urban Apartment (Non-Natural) video.

The cognitive performance index which is ratio between *beta* and (*alpha + theta)* waves shows a relative increase with respect to the blank screen readings as shown in figure 4.7. But, the increase is more in case of the subject viewing the Urban Apartment (Non-Natural) video.
The Neural activity index which is ratio between *beta* and *theta* waves shows a relative decrease with respect to the blank screen readings as shown in figure 4.8. But, the decrease is more in case of the subject viewing the Underwater vegetation (Natural) video.

The Synchronization index which is ratio between *delta* and *theta* waves shows a relative decrease with respect to the blank screen readings as shown in figure 4.9. But, the decrease is more in case of the subject viewing the Underwater vegetation (Natural) video.

The Desynchronization index which is ratio between *alpha* and *beta* waves shows a relative decrease with respect to the blank screen readings as shown in figure 4.10. But, the decrease is more in case of the subject viewing the Urban Apartment (Non-Natural) video.

The Vigilance index which is ratio between (*alpha + theta)* and *beta* waves shows a relative decrease with respect to the blank screen readings as shown in figure 4.11. But, the decrease is more in case of the subject viewing the Urban Apartment (Non-Natural) video.

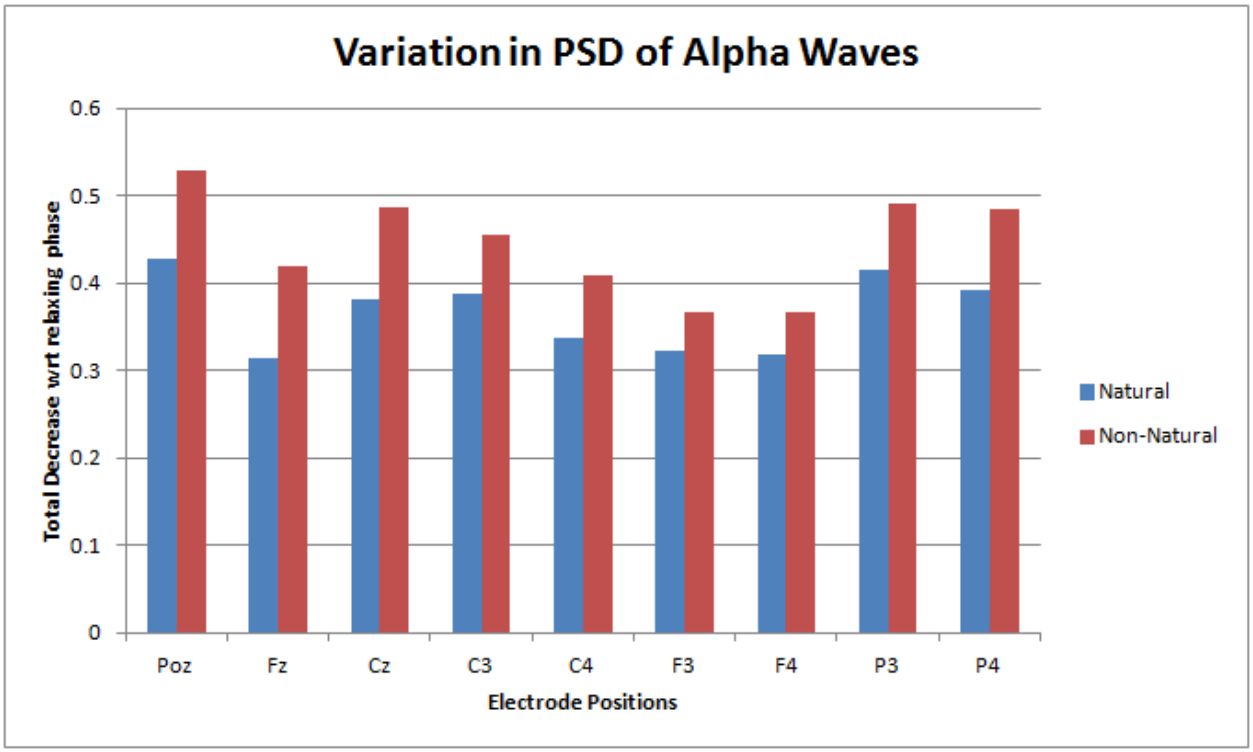


Figure 4.1

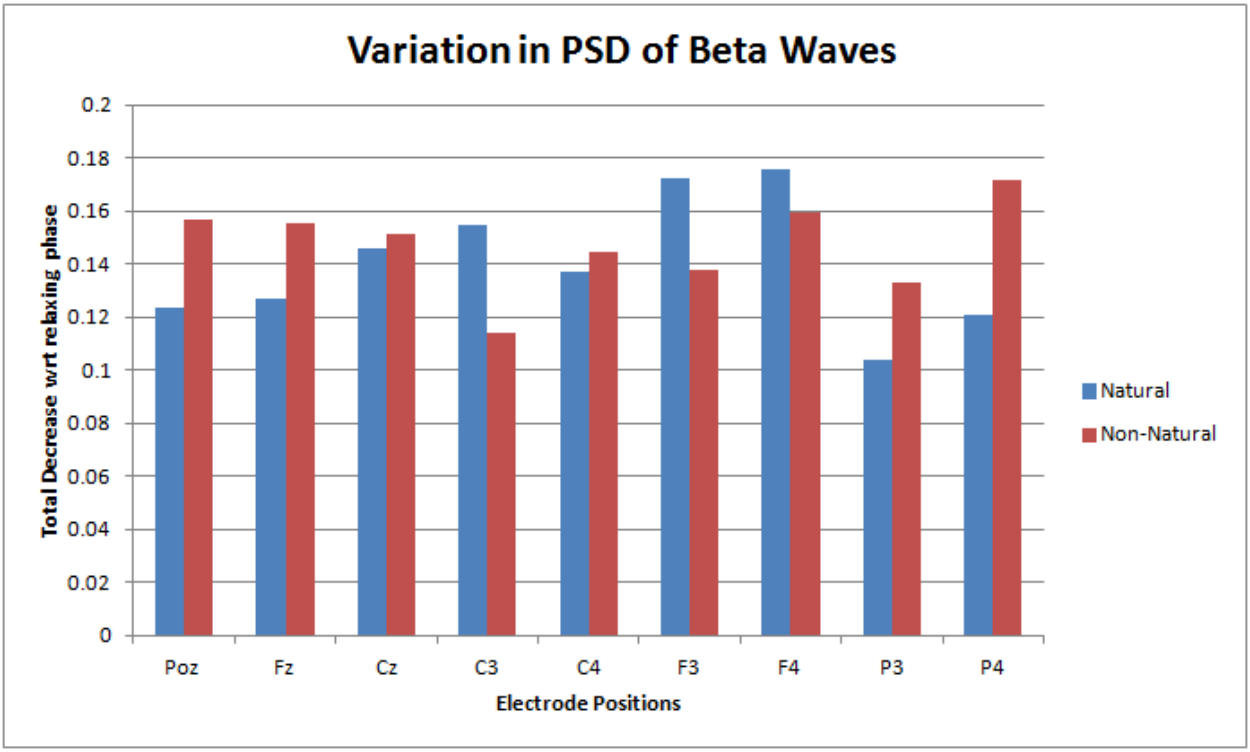


Figure 4.2

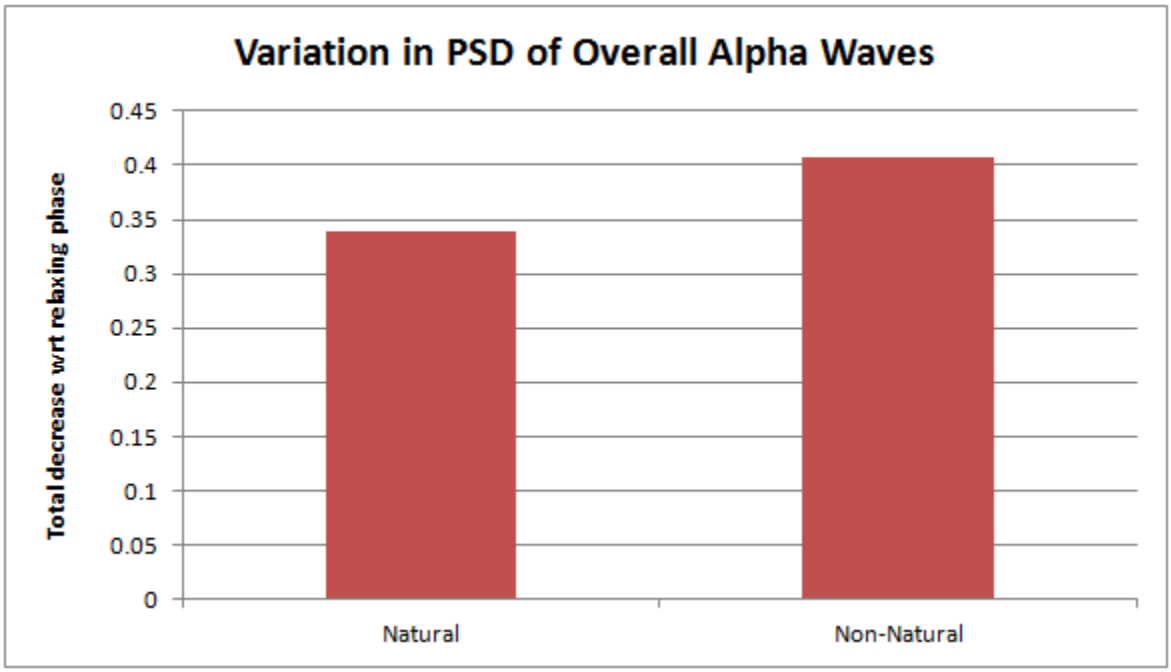


Figure 4.3

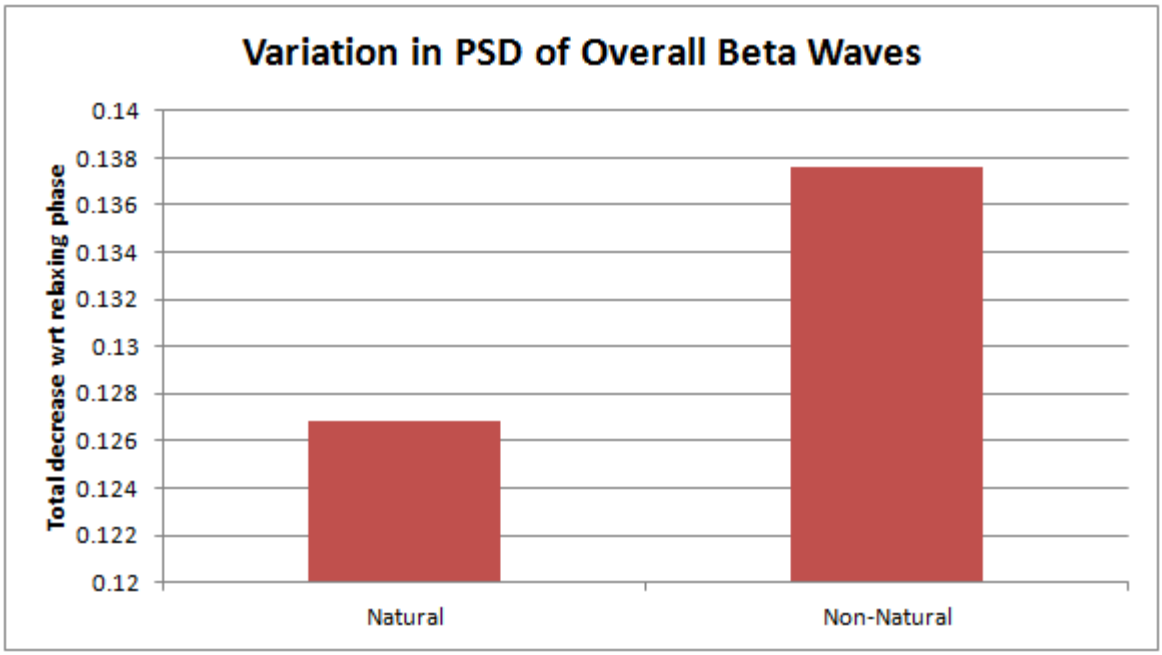
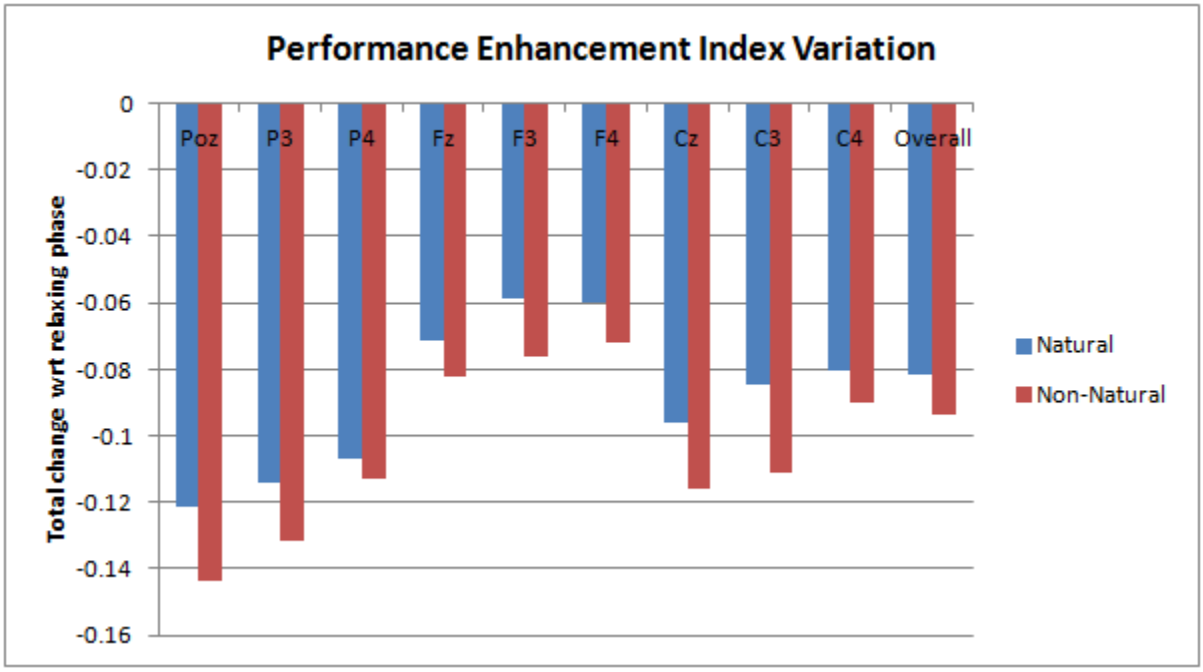


Figure 4.4



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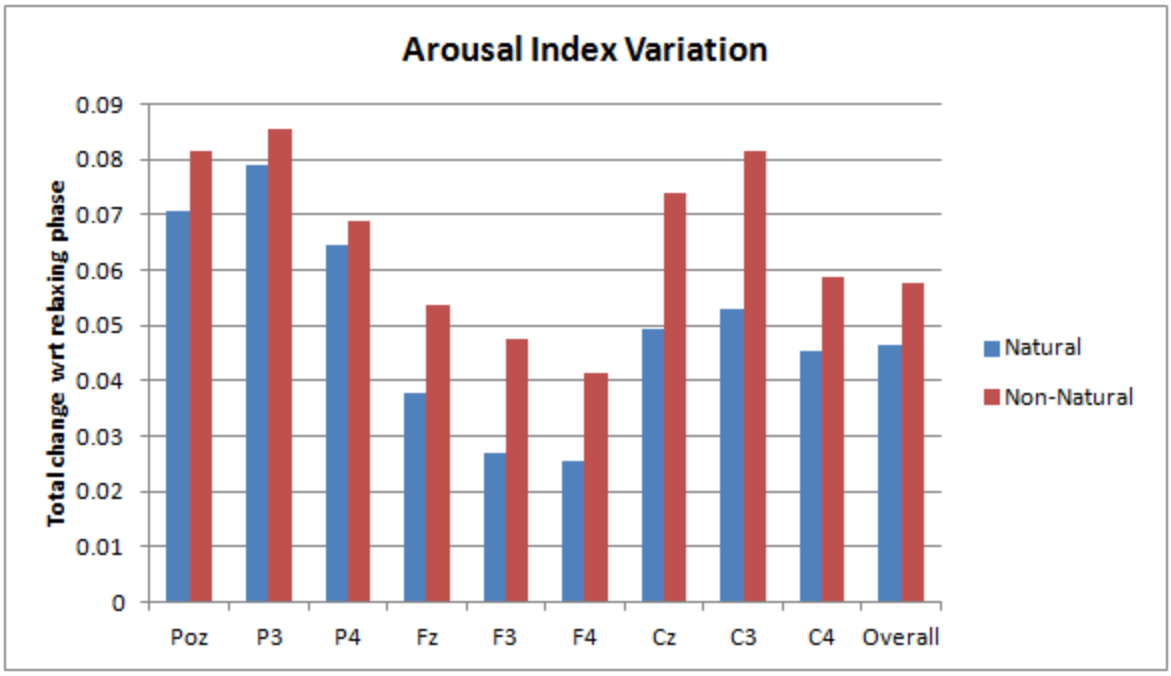

Figure 4.6

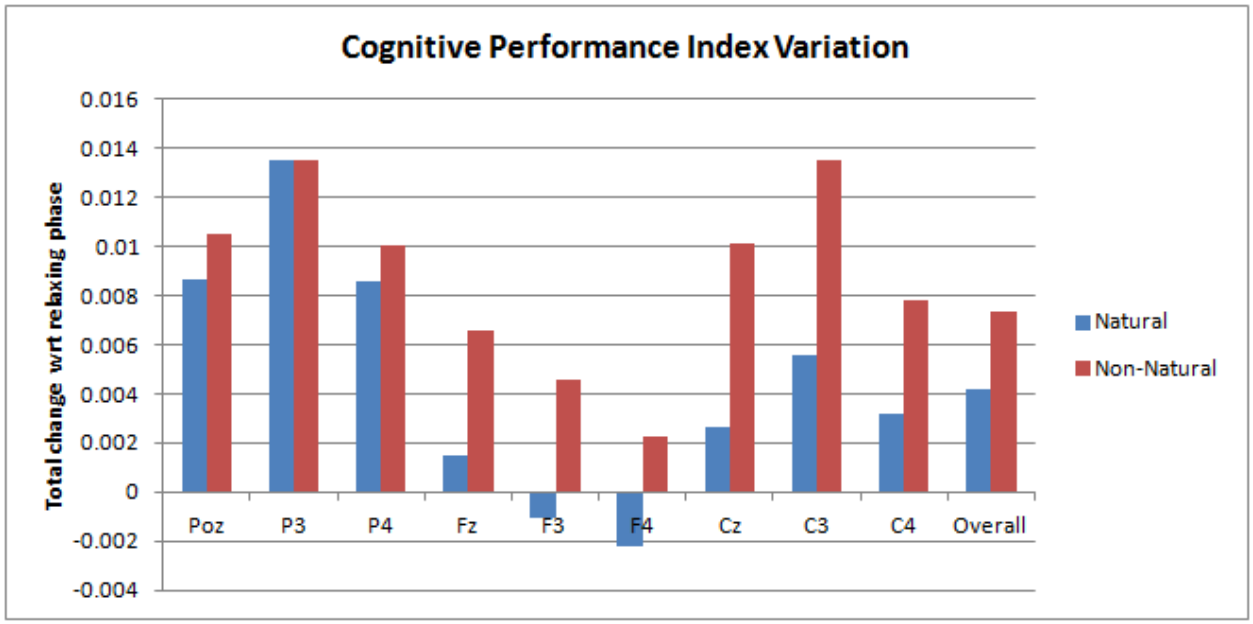

Figure 4.7

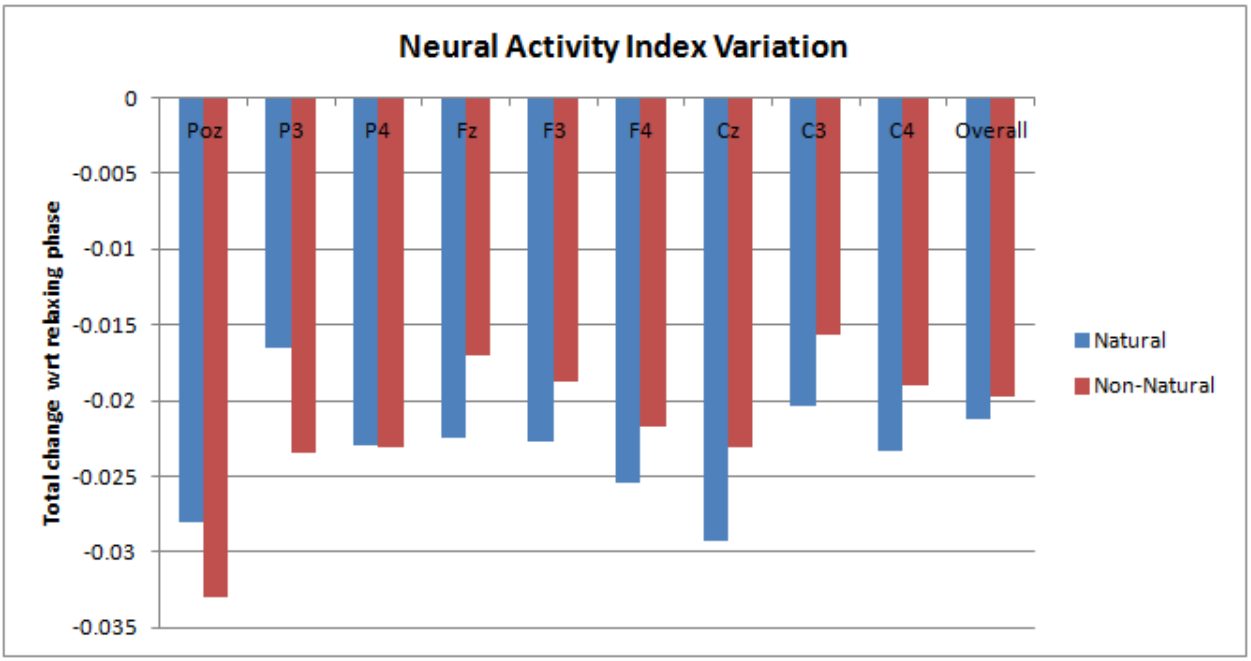

Figure 4.8

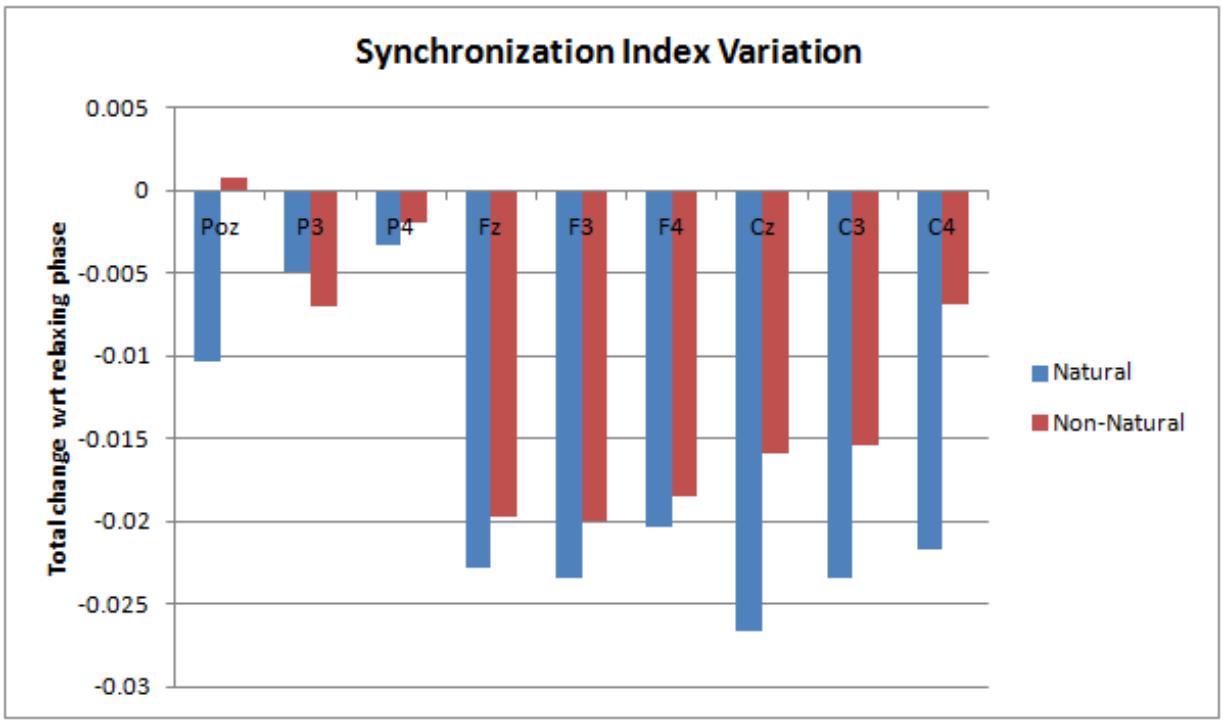

Figure 4.9

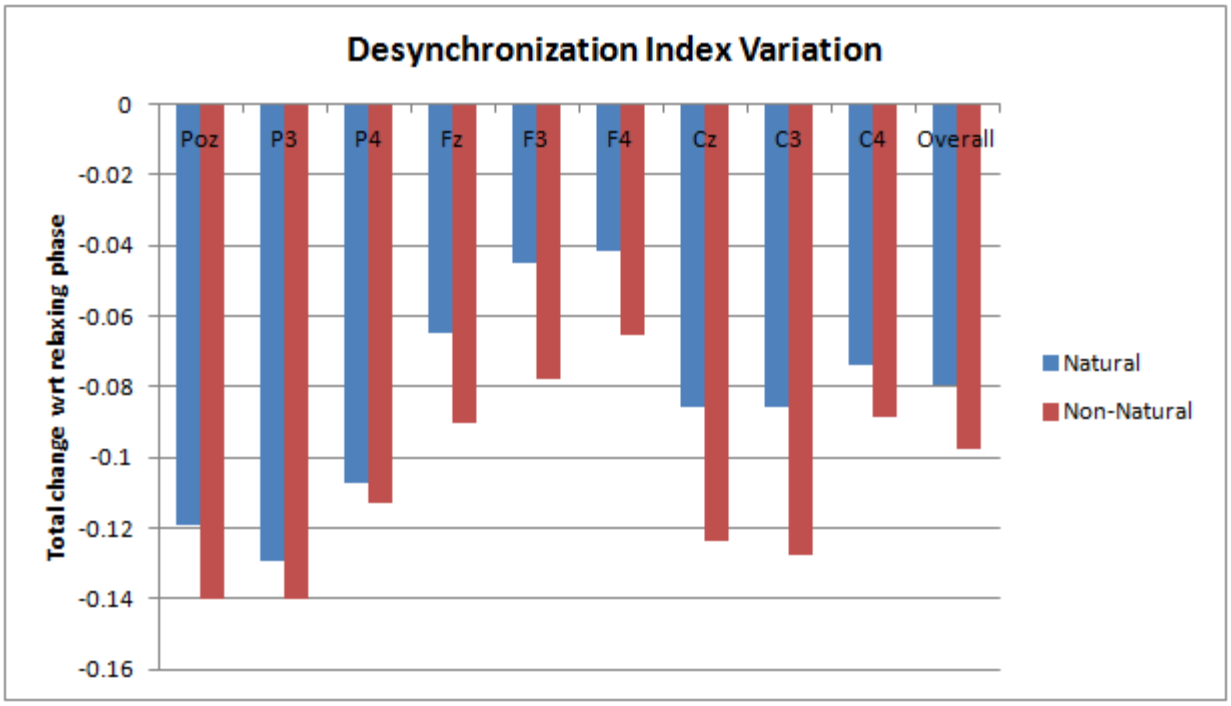

Figure 4.10

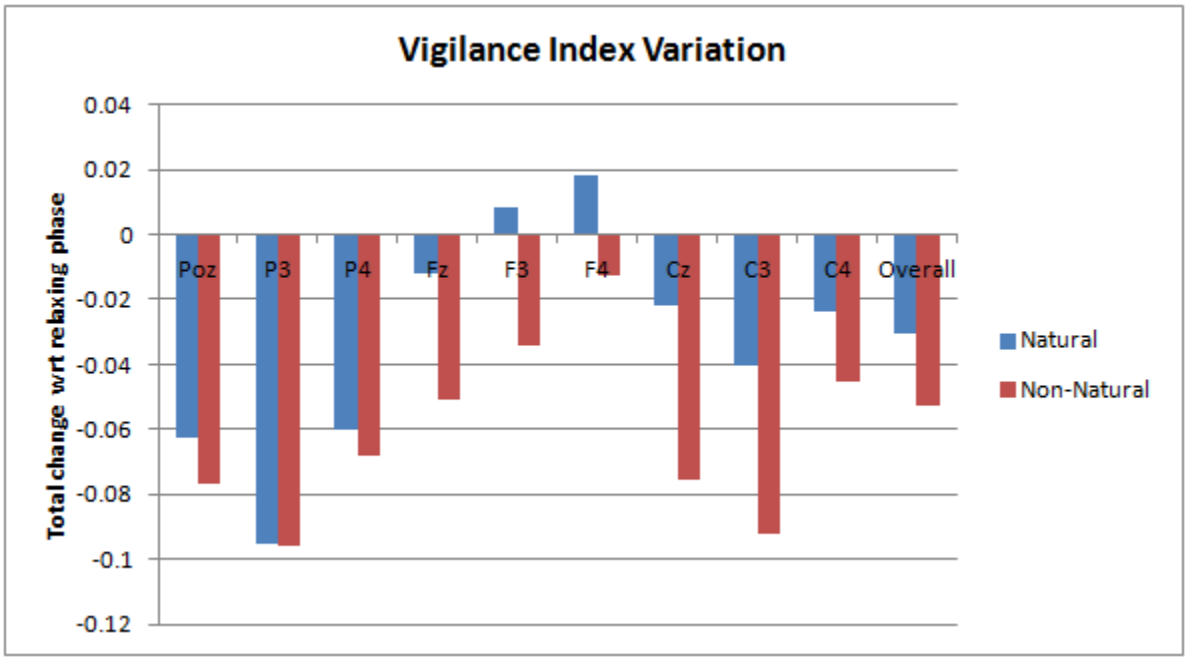

Figure 4.11

For predicting the % change in decrease of PSD of Alpha waves, we used the stepwise linear regression on our dataset of 15 subjects. The results of the prediction are shown in figure 4.12. The Pearson Correlation Coefficient (P) between the actual % decrease values & predicted % decrease values came out to be 0.840742. The Spearman Correlation Coefficient (S) came out to be 0.878571. Since S > P, the relationship between the dependent & independent variables is not linear but monotonic. So, we applied a logarithmic transformation on the dependent variable.

The Spearman Correlation Coefficient from our final model came out to be 0.896429. The summary of our final model is as follows:-

- Multiple R-squared: 0.786
- Adjusted R-squared: 0.727
- F-statistic: 13.4 on 3 and 11 DF
- p-value: 0.000537

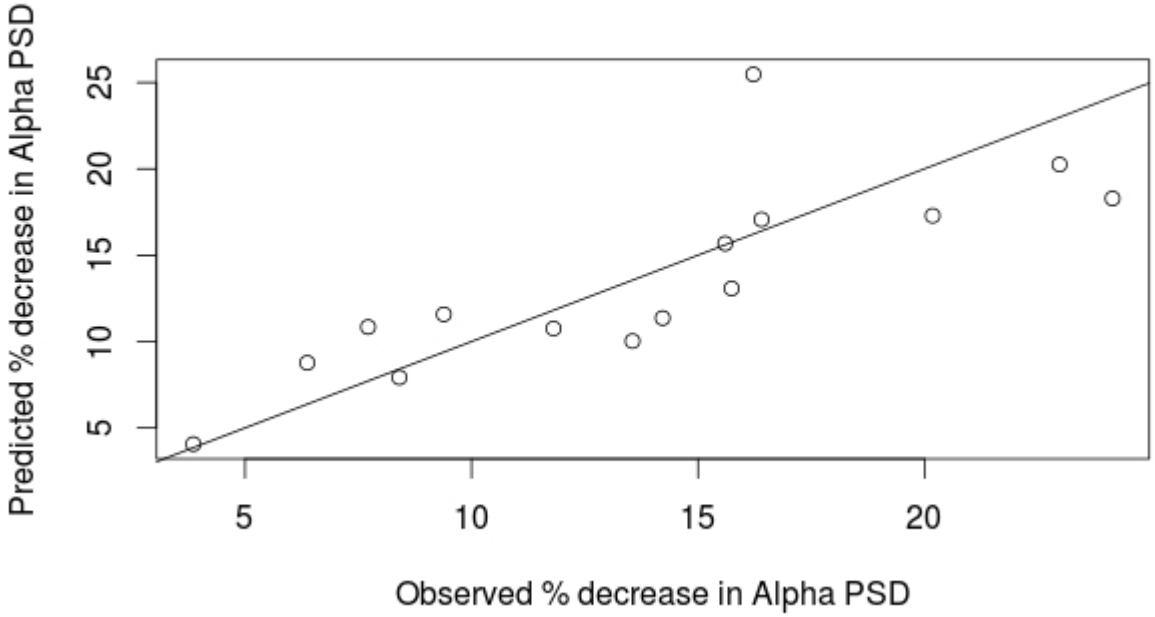

Figure 4.12: Graph between Predicted & Observed values of % decrease in PSD of alpha waves (using stepwise regression on 3 variables)

5. CONCLUSION

Alpha rhythm increase is associated with inward attention and is inversely proportional to mental activity. It is believed that alpha suppression reflects attention processes. Recent evidence indicates that different frequency bands within the extended alpha frequency range reflect quite different cognitive processes. Upper alpha desynchronization (in the range of about 10.5–12.5 Hz) is selectively associated with the processing of sensory-semantic information while desynchronization in the broad range of about 6.5–10.5 Hz reflects attention processes. In our case it was external stimuli, hence we observed alpha desynchronization (both upper and lower alpha) in both cases, but alpha is decreasing less in natural scenes, suggesting more attention is required in urban scenario and natural views are more relaxing (attention and relaxation are inverse).

Also, we observed beta desynchronization in both the cases. According to literature, beta ERD is associated with motor response, however there are many studies which indicate beta ERD's association with motor imagery and actual motion. In fact, beta ERD was observed when subjects listened passively to infrequent lateralized syllables interspersed in a sequence of frequent midline events. We can suggest that our video activated the motor networks of brain.
However beta has been associated with visual attention too. It has been observed that beta enhances during visual attention.This paradox or confusion is discussed in later section.

The arousal index is used in sleep EEG study and depicts wakeful state (active). In our case, arousal activity increased in both cases but increased more in urban landscape. The cognitive performance & attentional resource index tracks the demand for sensory processing and attentional resources. This index has increased on an average in both cases, though the increase is more in urban landscape, suggesting that more attentional resources are used in urban scenes. The neural activity index decreased in both the cases with more decrease corresponding to natural landscape. People with fast learning capabilities show more decrease in neural activity index.

EEG synchronization is an electrophysiological correlate of deactivated cortical areas. While viewing more engaging scenes, the synchrony of the cluster of neurons is deactivated more profoundly. That's why the synchronization index decreased more in the case of natural scenes as compared to the urban scenes. EEG desynchronization is a reliable correlate of excited neural structures or activated cortical areas. More profoundly the deactivation of neurons occur, less profound will be their activation. So, the desynchronization index decreased more in case of urban scenes as compared to the natural scenes.

Vigilance index is another measure for alertness and sustained attention. Since we benchmarked our model against blank screen (no video being played), the vigilance index would supposedly decrease in both cases where more attention is required. However, it decreased more in case of subject watching the urban landscape.

6. FUTURE WORK & DISCUSSIONS

Many studies have shown that natural view has more positive influence on emotional states than urban views. This project is another evidence on the similar lines. However this whole experiment was conducted in laboratory environment. If another research conducted where subject was actually moving in wilderness confirms this hypothesis, then we can also say that such experiments involving nature can be performed in lab.

Most of the studies suggest increase in alpha activity significantly while viewing nature thus contradicting our readings. This suggests that viewing nature on screen is different from viewing nature otherwise. This also means that natural video is nothing but a task involving visual attention, thus causing alpha desynchronization.

We hypothesized increase in beta, as increased visual attention should increase beta. This paradoxical increase in beta is explained as increase in beta in only those parts which are solely involved in visual attention. Skin electrodes tend to average EEG signal from a large area of the occipital cortex and the amplitude largely depends on the synchronization of all contributing sources. Accordingly, cortical activity of small amplitude but synchronized over large cortical areas may be recorded as a relatively strong signal compared to a highly synchronized but limited neuronal pool.

We would also suggest not to use motion in videos/stimuli as there is a possibility of activating motor networks in brain, which will be indicated in beta waves, or at least take this in account.

One field where it may find application is if such VR can be developed which can replicate the feeling of being in natural environment accurately then it is possible to experience distant places without actually going there.

Apart from these, there were many limitations in this study. VR headset cannot substitute the real natural view, hence EEG of the stimuli is not exactly replica of viewing true nature.
Also we are assuming that state of mind during black screen case are identical, but there are possibility of both being different.

Due to constraints of time and resources, number of subjects were limited to 15.

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