# Electroencephalography Based Analysis of Emotions Among Indian Film Viewers

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**Abstract.** The film industry has been a major factor in the rapid growth of the Indian entertainment industry. While watching a film, the viewers undergo an experience that evolves over time, thereby grabbing their attention. This triggers a sequence of processes which is perceptual, cognitive and emotional. Neurocinematics is an emerging field of research, that measures the cognitive responses of a film viewer. Neurocinematic studies, till date, have been performed using functional magnetic resonance imaging (fMRI); however recent studies have suggested the use of advancements in electroencephalography (EEG) in neurocinematics to address the issues involved with fMRI. In this article the emotions corresponding to two different genres of Indian films are captured with the real-time brainwaves of viewers using EEG and analyzed using R language.

**Keywords:** EEG · Indian film · Neurocinematics · Cognitive review · BCI

## 1 Introduction

The advancements in functional neuroimaging procedures have enabled researchers to measure the activities of brain when viewers watch a film, leading to increased research focus in the area of neuroscience. The term neurocinematics was coined by Hasson et al. [1, 2], they used functional magnetic resonance imaging (fMRI) to capture the viewer's emotion during viewing of films. A new method called inter-subject correlation (ISC) was introduced by them [1, 2], which highlighted the simultaneous activation of similar brain regions for different people. This method (ISC) was considered as a new way of reviewing films to get better responses. Even though the functional magnetic resonance (fMRI) based method offered a new dimension of reviewing a film, the method has its own drawback when considered for practical implementation of neurocinematics. Firstly, the environment where the fMRI based reviewing method is carried out is entirely different from the environment in which viewers watch film in theatre. In Hasson et al.'s study, the viewers were lying inside a MRI scanner, which has a small amount of space compared to normal viewing conditions and hence expressing their natural responses would have been difficult. Secondly, a viewer's emotion might vary based on the number of people they are watching a film with, for instance, a viewer watching a comedy clip alone would express lesser emotions as


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compared to one who is viewing the same clip with partners. Thirdly, fMRI is an expensive procedure among all neuroimaging techniques and experimenting this procedure for a large number of subjects can be considered only after measuring the reliability of the experiment. Finally, EEG has the capability to detect changes within a millisecond timeframe, which is excellent considering the fact that movie scenes change quickly.

Synchronized neural activities in the brain give rise to EEG signals, which can be studied by placing the EEG electrodes near the scalp or on the scalp (Non-invasive method) [3] or by implanting the EEG electrodes in the skull (Invasive method). Mostow et al. [4] noted that development, mental state, and cognitive activity influenced the synchronized neural activity, and the variations in neural activity could be measurably detected by EEG signals. For instance, within particular frequency bands, the EEG signals undergo rhythmic fluctuations, each frequency band correlates with different emotional states of brain like concentration, anxiety and anger, as observed in various tasks and characteristics [5–7].

Hospitals and laboratories have been using multi-electrode EEG systems for a long time, but the trending EEG devices which are economical, have made it possible to use the concept of EEG for large-scale purposes. For example, the Neurosky Mindwave Mobile, Fig. 1 (used in this experiment). The device consists of a headset, an ear clip and a sensor arm.

**Fig. 1.** The Mindwave Mobile, picture taken from [8]

The headset's reference and ground electrodes are on the ear clip and the EEG electrode is on the sensor arm, which rests on the forehead above the eye (Fp1) [8], as shown in Fig. 2. Moreover, this device requires no gel or saline for recording as compared to other devices in lab, along with noise-cancellation [10]. Bluetooth/BLE is used for integration between the computer and Mindwave Mobile.

The Mindwave, though constrained with having a single, dry sensor, and studied with untrained users, gave an accuracy of 86% while differentiating various states [10]. Secondly, the Mindwave is also found to be more resistant to noise than the Biopac

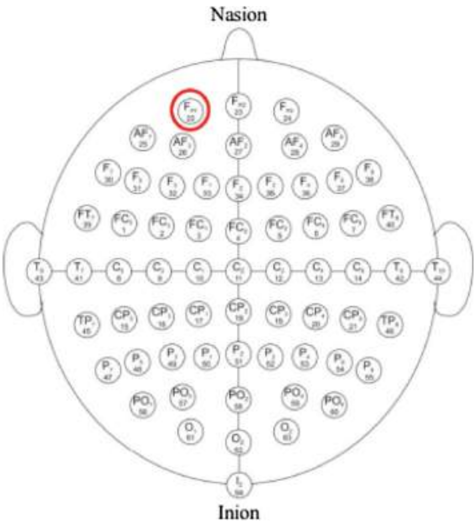


**Fig. 2.** The ten-twenty 64-electrode system of the International Federation [9], picture was taken from [11]. The red circle at the top indicates Fp1. (Colour figure online)

system since Mindwave uses shorter wires for EEG signal transmission. Thus, the device has been used in this experiment.

The rest of the paper is methodized as follows. Section 2 deals with the Literature Review of previous articles related to this field. Section 3 showcases the Wave Graph and Power Spectrum of two volunteers watching two movies each. In the same section, further, the data is loaded and analyzed using R language. Section 4 concludes the article. Finally, in Sect. 5, Future works and research scope of this field are discussed, followed by References.

## 2 Literature Review

The proposals in this article are alternate versions of functional magnetic resonance imaging (fMRI), which is a neuroimaging procedure that detects the changes in blood flow to track brain activities. The fact that the cerebral blood flow and neuronal activations are coupled, is used in this technique. When an area of brain is active, the blood flow to that region of the brain increases.

The output of the MRI scanner is reprogrammed to get three dimensional images of the brain varying continuously with time. If there is an increase in neural activity in a certain region of brain, then the intensities of images at that part of the brain increases. It was also observed that cinema viewing involves high spatiotemporal complexity, hence the conventional fMRI methods were not found to be useful, therefore a new method known as intersubject correlation [2] was devised, which measured the similarities in the brain activities among all cinema viewers.

While Hasson et al. [1, 2] used ISC method for neurocinematic experiments, the model of Narrative Nowness for neurocinematic experiments was proposed by Janne et al. [12], they highlighted the fact that the fMRI experiment by Hasson et al. showed significant inter-subjective correlation between the brain responses of viewers of a Hitchcock film, but that did not hold for those watching a random surveillance video footage. Therefore Janne et al. suggested that the similarity of brain behavior between viewers was likely due to the way their attention was trapped, guided, and tricked by the narrative design that was a system of temporal contexts.

Janne et al. [12] also pointed out that, the mere comparison of context annotation of features present at a given moment with the synchronized brain responses may not alone provide a sufficient basis for naturalistic neurosciences to understand higher levels of cognitive functions, they suggested that neuroscientific studies that neglected the viewer's temporal situatedness with respect to continuous narrative just fell short of meeting the attribute 'naturalistic.' They proposed another layer of representing the narrative to relate it to the brain activity.

These published articles have lot of merits, as they provided a breakthrough for taking the live responses of films and also traced the brain activities of different viewers, capturing the live responses, hence giving an overall precise review for each section of a film. The disadvantage with these methods is that, every MRI scan is time consuming and tedious.

## 3 Observing Brainwaves During Film Viewing

In this experiment performed to study the brainwaves during film viewing, two volunteers, each were asked to view the opening 15 min of two different genres of Indian films - Maya, a well known horror film by Ashwin Saravanan (2015) and Thillu Mullu, a well known comedy film by K. Balachander (1981). The volunteers were scanned by using EEG devices. High definition video and audio were supplied to the subjects. The High definition video was presented in a laptop. Sound was delivered through earphones. The volunteers were allowed to watch the movie without any hindrance. The raw EEG data was analyzed using the NeuroView software and simultaneously raw waves were converted to digital data, which was analyzed using R language to get a final value of frequencies (corresponding to different emotions) for a specified time interval for each movie.

The x-axis on each of the raw wave graphs, shows one second at a time. Each second gives 512 data points. The y-axis shows values that are simply called NeuroView units and are not defined in a more specific way [13].

In the histogram, the x-axis represents time interval and the y-axis represents frequency.

It is to be noted that the Raw Brainwaves and Power Spectrum observed, are similar for volunteers watching the same genre of films, as shown in Figs. 3 and 4 for the comedy genre, and Figs. 5 and 6 for the horror genre. This conveys the fact that the movies of various genres had a similar effect on both the viewers.

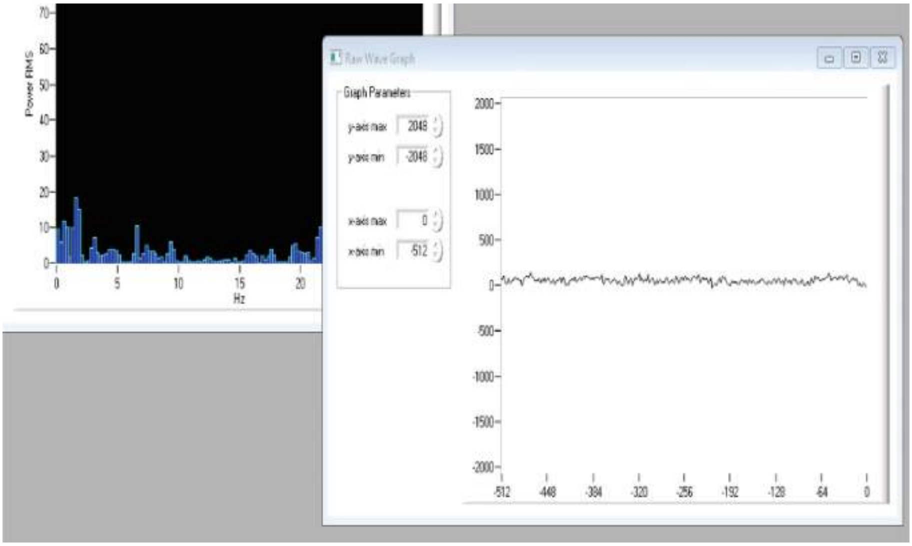


**Fig. 3.** This shows the Raw Brainwave and Power Spectrum (as viewed in NeuroView) of volunteer 1 watching the film Thillu Mullu. The genre of movie is comedy, the subject is a male in the age category 20–25.

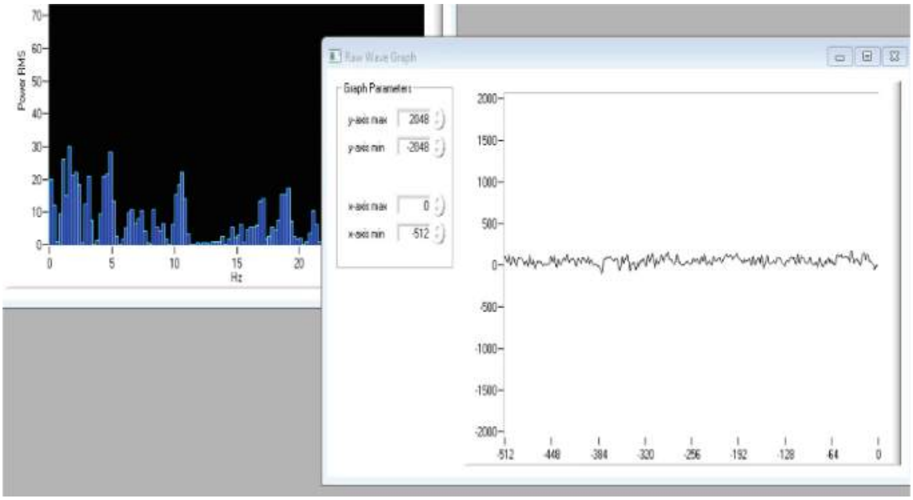


**Fig. 4.** This shows the Raw Brainwave and Power Spectrum (as viewed in NeuroView) of volunteer 2 watching the film Thillu Mullu. The genre of movie is comedy, the subject is a male in the age category 20–25.

The values obtained from the graph are broadly classified into 4 regions, namely, alpha, beta, theta and delta. The delta waves occur in the region of 0–4 Hz, the theta waves occur in the region of 4–8 Hz, the alpha waves occur in the frequency range of

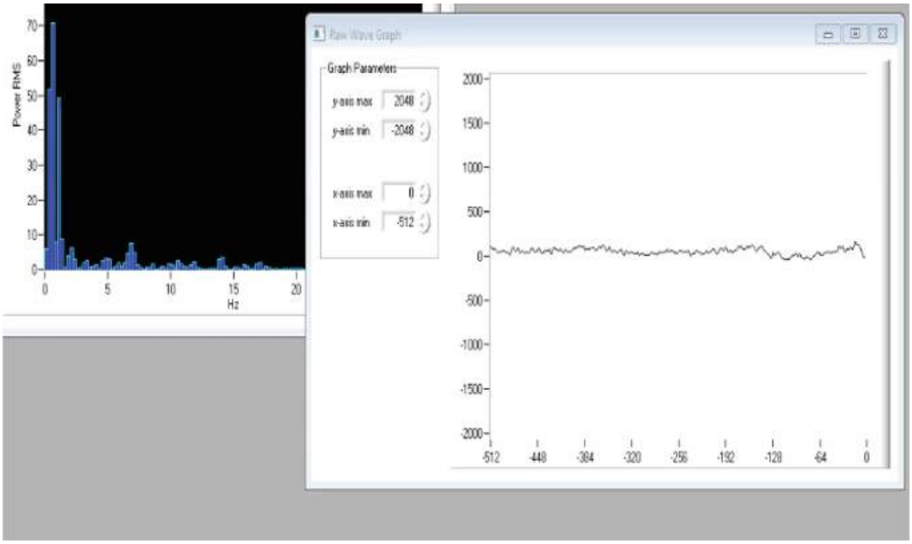


**Fig. 5.** This shows the Raw Brainwave and Power Spectrum (as viewed in NeuroView) of volunteer 1 watching the film Maya. The genre of movie is horror, the subject is a male in the age category 20–25.

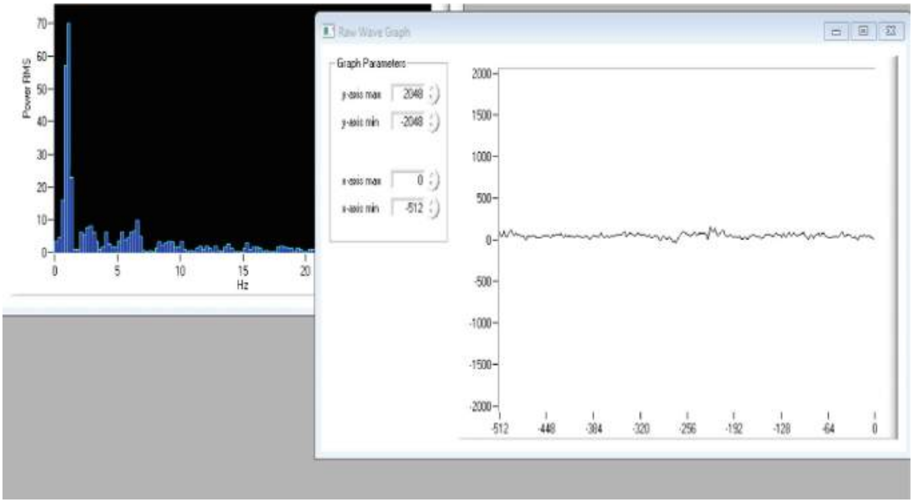


**Fig. 6.** This shows the Raw Brainwave and Power Spectrum (as viewed in NeuroView) of volunteer 2 watching the film Maya. The genre of movie is horror, the subject is a male in the age category 20–25.

8–14 Hz, the beta waves occur in the frequency range of 14–30 Hz, and the gamma waves occur in the region of 30–50 Hz. Each wave has a set of emotions associated with them. Beta waves are associated with attentiveness, alertness and engagement in mental activity. Alpha waves are associated with calmness, relaxed, anti–depressed states. Theta waves are associated with vivid imagery, and where we hold our fears, troubled history and nightmares. Delta waves are associated with deep dreamless sleep and are found wane with rise in age, while gamma waves are very high frequencies and involve rapid processing of information. Therefore the latter two waves are ignored in this study, as it does not correspond to any specific emotion in Neurocinematics.

### 3.1 Using R Language to Analyze the Obtained Dataset

The R language is used to perform analysis on the large data set that is obtained. The data is loaded into R studio in the form of a CSV file, the obtained data set consists of the powers of brainwaves across all frequencies at a time gap of one second, as shown in Fig. 7. Using R programming the mean value at a particular second is calculated for each power spectrum, the highest value among all values is considered as the final value for that particular time interval.

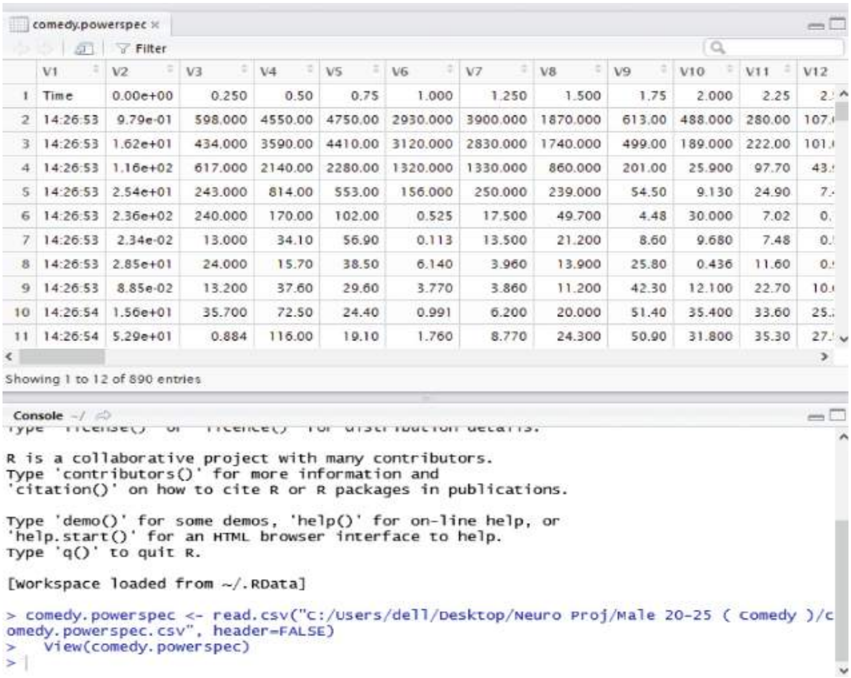


**Fig. 7.** This shows sample data loaded in R Studio, the first row in data set represents time shows and the first column represents frequency.

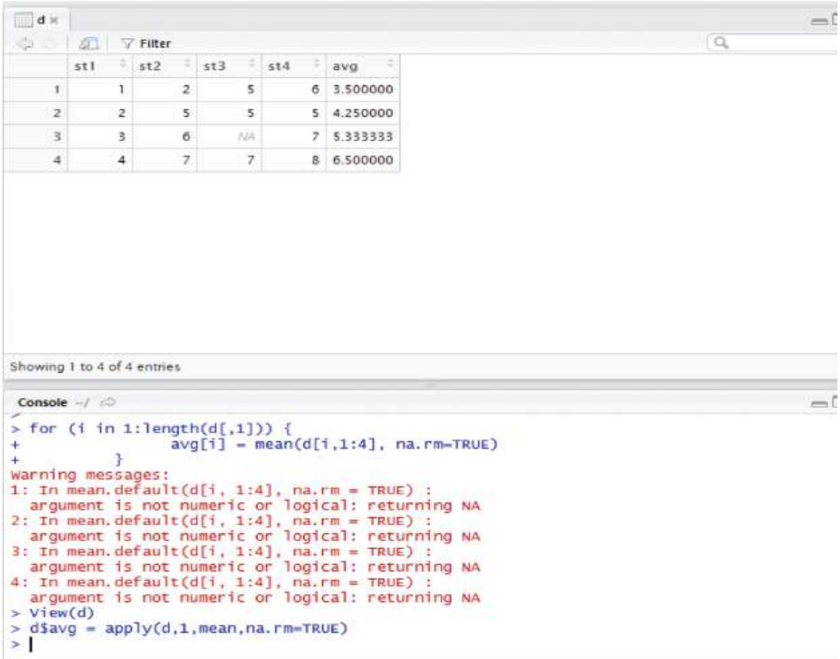


**Fig. 8.** This shows sample values for which row-wise mean was calculated using R language, and the maximum value in the average column is taken as the final value.

Mean is calculated row-wise across suitable frequencies (e.g., 4–8 Hz for Theta wave) as shown in Fig. 8. The mean is calculated using R language as follows,

```
data_frame$means <- apply(data_frame, 1, mean)
```

When the above methods were applied to the horror clip viewed by both volunteers, the theta wave was observed as the most powerful wave, but it was closely preceded by alpha or beta wave of higher frequencies at every instance, this indicated the fact that volunteers were constantly oscillating between the states of anxiety and relaxation. This shows that the film has captured viewers' attention at every second. Whenever the ghost appears, theta wave spikes. It then returns to a normal state in a few seconds, while alpha wave is observed for a scene involving the peaceful scenes of protagonist (Fig. 9).

The result data set was totally different for comedy film, where, alpha wave was observed almost every second, indicating the fact that volunteer was constantly in a state of anti-depression (was happy) during the movie. Moreover, beta wave is also showing the engagement of the viewer into the comedy movie. The observation of alpha and beta waves throughout has indicated that the viewer was completely engrossed in the film (Fig. 10).

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5.82E-14 | 5.60E-14 | 5.74E-14 | 5.33E-14 | 5.08E-14 | 5.06E-14 | 4.95E-14 | 4.86E-14 | 4.81E-14 | 4.77E-14 | 2.041634 | |
| 1.60E-14 | 1.76E-14 | 1.07E-14 | 1.14E-14 | 8.78E-15 | 7.76E-15 | 6.51E-15 | 5.53E-15 | 4.87E-15 | 4.47E-15 | 0.054425 | |
| 3.94E-15 | 4.12E-15 | 1.73E-15 | 2.91E-15 | 1.70E-15 | 1.83E-15 | 1.52E-15 | 1.37E-15 | 1.25E-15 | 1.18E-15 | 1.06E-08 | |
| 1.28E-13 | 1.26E-13 | 1.34E-13 | 1.29E-13 | 1.25E-13 | 1.25E-13 | 1.23E-13 | 1.22E-13 | 1.21E-13 | 1.21E-13 | 19.486 | |
| 4.83E-15 | 2.12E-15 | 2.09E-15 | 1.71E-15 | 1.60E-15 | 1.62E-15 | 1.52E-15 | 1.44E-15 | 1.40E-15 | 1.37E-15 | 2.082765 | theta |
| 5.73E-14 | 5.70E-14 | 5.61E-14 | 5.05E-14 | 4.97E-14 | 4.86E-14 | 4.69E-14 | 4.57E-14 | 4.49E-14 | 4.44E-14 | 1.626667 | |
| 3.28E-14 | 2.05E-14 | 2.67E-14 | 2.28E-14 | 2.41E-14 | 2.40E-14 | 2.39E-14 | 2.38E-14 | 2.38E-14 | 2.38E-14 | 0.93828 | |
| 3.00E-14 | 3.56E-14 | 3.76E-14 | 3.07E-14 | 3.25E-14 | 3.11E-14 | 3.04E-14 | 2.99E-14 | 2.96E-14 | 2.93E-14 | 0.612124 | |
| 6.33E-14 | 6.18E-14 | 6.35E-14 | 5.30E-14 | 5.57E-14 | 5.24E-14 | 5.13E-14 | 5.00E-14 | 4.93E-14 | 4.88E-14 | 0.2579 | |
| 2.25E-14 | 1.46E-14 | 1.21E-14 | 8.53E-15 | 7.28E-15 | 4.81E-15 | 3.11E-15 | 1.74E-15 | 7.75E-16 | 1.96E-16 | 0.00622 | |
| 1.87E-13 | 1.61E-13 | 1.68E-13 | 1.65E-13 | 1.65E-13 | 1.63E-13 | 1.62E-13 | 1.61E-13 | 1.61E-13 | 1.60E-13 | 2.37E-09 | |
| 2.30E-14 | 1.25E-14 | 1.61E-14 | 1.27E-14 | 1.21E-14 | 1.16E-14 | 1.06E-14 | 1.01E-14 | 9.74E-15 | 9.52E-15 | 21.21271 | |
| 3.41E-13 | 2.97E-13 | 3.24E-13 | 2.98E-13 | 3.09E-13 | 3.00E-13 | 2.99E-13 | 2.97E-13 | 2.96E-13 | 2.95E-13 | 4.9217 | theta |
| 2.22E-13 | 1.73E-13 | 1.37E-13 | 1.21E-13 | 8.79E-14 | 7.08E-14 | 5.33E-14 | 4.04E-14 | 3.11E-14 | 2.56E-14 | 1.412111 | |
| 1.17E-14 | 8.66E-15 | 6.79E-15 | 8.41E-15 | 6.61E-15 | 5.88E-15 | 5.47E-15 | 5.03E-15 | 4.75E-15 | 4.57E-15 | 2.191333 | |
| 9.14E-14 | 8.97E-14 | 9.34E-14 | 8.82E-14 | 8.53E-14 | 8.63E-14 | 8.51E-14 | 8.42E-14 | 8.38E-14 | 8.34E-14 | 1.6037 | |
| 2.90E-13 | 2.62E-13 | 2.68E-13 | 2.61E-13 | 2.58E-13 | 2.55E-13 | 2.52E-13 | 2.51E-13 | 2.50E-13 | 2.49E-13 | 0.601647 | |
| 3.98E-14 | 3.12E-14 | 3.09E-14 | 2.78E-14 | 2.62E-14 | 2.43E-14 | 2.36E-14 | 2.24E-14 | 2.18E-14 | 2.14E-14 | 0.007578 | |
| 2.54E-13 | 2.20E-13 | 2.11E-13 | 2.09E-13 | 2.07E-13 | 1.99E-13 | 1.98E-13 | 1.95E-13 | 1.93E-13 | 1.92E-13 | 4.30E-09 | |
| 7.36E-14 | 4.96E-14 | 5.27E-14 | 5.15E-14 | 4.97E-14 | 4.87E-14 | 4.74E-14 | 4.66E-14 | 4.60E-14 | 4.56E-14 | 126.2689 | |
| 5.47E-14 | 7.65E-14 | 5.40E-14 | 4.66E-14 | 3.80E-14 | 3.16E-14 | 2.57E-14 | 2.13E-14 | 1.80E-14 | 1.61E-14 | 2.660224 | theta |
| 1.40E-13 | 1.01E-13 | 1.11E-13 | 1.04E-13 | 1.05E-13 | 1.02E-13 | 1.03E-13 | 1.02E-13 | 1.01E-13 | 1.01E-13 | 1.766333 | |
| 1.50E-14 | 2.44E-14 | 1.72E-14 | 1.48E-14 | 1.12E-14 | 8.79E-15 | 7.02E-15 | 5.43E-15 | 4.31E-15 | 3.65E-15 | 1.615489 | |
| 1.44E-13 | 1.21E-13 | 1.12E-13 | 1.21E-13 | 1.16E-13 | 1.16E-13 | 1.15E-13 | 1.15E-13 | 1.14E-13 | 1.14E-13 | 0.672832 | |
| 2.73E-14 | 2.37E-14 | 2.26E-14 | 1.69E-14 | 1.45E-14 | 1.20E-14 | 1.02E-14 | 8.70E-15 | 7.65E-15 | 7.00E-15 | 0.730269 | |
| 6.21E-14 | 6.96E-14 | 5.93E-14 | 6.19E-14 | 6.12E-14 | 6.08E-14 | 6.06E-14 | 6.02E-14 | 6.01E-14 | 6.00E-14 | 0.013078 | |
| 1.01E-14 | 1.19E-14 | 6.93E-15 | 7.03E-15 | 6.88E-15 | 5.96E-15 | 5.42E-15 | 5.07E-15 | 4.79E-15 | 4.63E-15 | 4.68E-09 | |
| 1.18E-13 | 1.26E-13 | 1.12E-13 | 1.14E-13 | 1.08E-13 | 1.08E-13 | 1.07E-13 | 1.06E-13 | 1.05E-13 | 1.05E-13 | 74.14176 | |
| 1.02E-14 | 1.03E-14 | 8.32E-15 | 4.73E-15 | 4.43E-15 | 2.82E-15 | 1.90E-15 | 1.12E-15 | 5.50E-16 | 2.11E-16 | 5.163347 | theta |
| 6.69E-14 | 4.51E-14 | 4.59E-14 | 4.42E-14 | 4.31E-14 | 4.05E-14 | 4.01E-14 | 3.91E-14 | 3.84E-14 | 3.80E-14 | 1.1016 | |
| 5.48E-14 | 3.75E-14 | 4.27E-14 | 3.84E-14 | 3.94E-14 | 3.94E-14 | 3.83E-14 | 3.81E-14 | 3.79E-14 | 3.78E-14 | 1.095356 | |
| 3.98E-15 | 3.89E-15 | 1.99E-15 | 2.05E-15 | 1.29E-15 | 1.06E-15 | 5.58E-16 | 3.38E-16 | 1.51E-16 | 3.85E-17 | 0.870308 | |
| 1.57E-14 | 1.52E-14 | 1.31E-14 | 1.45E-14 | 1.32E-14 | 1.35E-14 | 1.28E-14 | 1.28E-14 | 1.26E-14 | 1.26E-14 | 0.575435 | |
| 7.08E-14 | 6.13E-14 | 6.32E-14 | 6.15E-14 | 6.12E-14 | 6.22E-14 | 6.06E-14 | 6.09E-14 | 6.06E-14 | 6.05E-14 | 0.00633 | |

**Fig. 9.** The right most column is the final calculated value for the horror movie (Maya), and it is observed that theta waves are observed mostly, while alpha and beta waves (higher frequencies just above theta) precede theta waves.

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8.49E-14 | 1.18E-13 | 8.48E-14 | 1.16E-13 | 1.15E-13 | 9.19E-14 | 9.96E-14 | 9.65E-14 | 9.47E-14 | 9.42E-14 | 9.30E-14 | 9.24E-14 | 9.20E-14 | 162.9638 | |
| 1.55E-13 | 1.17E-13 | 1.13E-13 | 1.22E-13 | 9.87E-14 | 1.10E-13 | 9.73E-14 | 9.38E-14 | 8.89E-14 | 8.62E-14 | 8.35E-14 | 8.17E-14 | 8.06E-14 | 2.992588 | |
| 1.18E-13 | 2.71E-14 | 5.79E-14 | 3.29E-14 | 5.45E-14 | 4.30E-14 | 4.44E-14 | 4.34E-14 | 4.22E-14 | 4.14E-14 | 4.10E-14 | 4.07E-14 | 4.05E-14 | 4.774333 | l.alpha |
| 1.87E-13 | 4.90E-13 | 4.04E-13 | 3.98E-13 | 3.61E-13 | 3.77E-13 | 3.72E-13 | 3.66E-13 | 3.58E-13 | 3.57E-13 | 3.55E-13 | 3.53E-13 | 3.52E-13 | 1.733333 | |
| 1.30E-13 | 3.39E-13 | 2.64E-13 | 1.96E-13 | 2.74E-13 | 2.27E-13 | 2.22E-13 | 2.31E-13 | 2.25E-13 | 2.24E-13 | 2.23E-13 | 2.22E-13 | 2.22E-13 | 2.03164 | |
| 7.40E-14 | 5.26E-14 | 3.01E-15 | 5.82E-15 | 6.55E-15 | 3.78E-15 | 2.51E-15 | 3.88E-15 | 2.85E-15 | 3.11E-15 | 2.96E-15 | 2.90E-15 | 2.88E-15 | 1.207727 | |
| 3.17E-13 | 9.53E-14 | 9.31E-14 | 1.09E-13 | 9.26E-14 | 9.66E-14 | 9.36E-14 | 9.11E-14 | 9.21E-14 | 8.91E-14 | 8.89E-14 | 8.83E-14 | 8.80E-14 | 0.031313 | |
| 1.30E-13 | 3.65E-13 | 2.32E-13 | 2.51E-13 | 1.85E-13 | 2.23E-13 | 2.17E-13 | 2.10E-13 | 2.10E-13 | 2.08E-13 | 2.06E-13 | 2.06E-13 | 2.05E-13 | 3.71E-08 | |
| 1.18E-13 | 4.32E-14 | 5.64E-14 | 8.69E-14 | 7.14E-14 | 7.17E-14 | 7.40E-14 | 6.97E-14 | 6.93E-14 | 6.93E-14 | 6.90E-14 | 6.87E-14 | 6.86E-14 | 10.42471 | |
| 2.43E-13 | 3.28E-13 | 3.61E-13 | 2.30E-13 | 3.13E-13 | 2.70E-13 | 2.85E-13 | 2.74E-13 | 2.73E-13 | 2.69E-13 | 2.68E-13 | 2.67E-13 | 2.66E-13 | 1.205624 | |
| 1.93E-13 | 1.21E-13 | 1.32E-13 | 1.17E-13 | 1.28E-13 | 1.03E-13 | 1.18E-13 | 1.11E-13 | 1.09E-13 | 1.10E-13 | 1.09E-13 | 1.09E-13 | 1.09E-13 | 2.203356 | l.alpha |
| 3.79E-14 | 1.89E-14 | 4.40E-14 | 7.41E-15 | 1.30E-14 | 1.81E-14 | 1.15E-14 | 1.38E-14 | 1.24E-14 | 1.24E-14 | 1.22E-14 | 1.21E-14 | 1.20E-14 | 1.967556 | |
| 2.41E-13 | 1.15E-13 | 6.62E-14 | 1.20E-13 | 9.32E-14 | 1.09E-13 | 9.52E-14 | 1.01E-13 | 9.76E-14 | 9.82E-14 | 9.75E-14 | 9.72E-14 | 9.71E-14 | 1.473608 | |
| 1.08E-13 | 7.28E-14 | 2.90E-14 | 4.43E-14 | 5.85E-14 | 4.67E-14 | 4.78E-14 | 4.74E-14 | 4.49E-14 | 4.54E-14 | 4.47E-14 | 4.43E-14 | 4.41E-14 | 1.101501 | |
| 2.71E-12 | 1.99E-12 | 2.34E-12 | 2.14E-12 | 2.05E-12 | 2.09E-12 | 2.06E-12 | 2.05E-12 | 2.03E-12 | 2.02E-12 | 2.01E-12 | 2.00E-12 | 2.00E-12 | 0.02485 | |
| 2.51E-14 | 1.55E-14 | 9.12E-17 | 1.36E-14 | 4.31E-15 | 3.41E-15 | 3.49E-15 | 3.48E-15 | 3.16E-15 | 2.93E-15 | 2.79E-15 | 2.70E-15 | 2.65E-15 | 1.33E-08 | |
| 2.82E-12 | 2.60E-12 | 2.44E-12 | 2.50E-12 | 2.31E-12 | 2.34E-12 | 2.30E-12 | 2.26E-12 | 2.25E-12 | 2.22E-12 | 2.21E-12 | 2.20E-12 | 2.19E-12 | 11.81306 | |
| 5.15E-12 | 4.98E-12 | 5.26E-12 | 4.49E-12 | 4.82E-12 | 4.59E-12 | 4.59E-12 | 4.55E-12 | 4.52E-12 | 4.48E-12 | 4.46E-12 | 4.44E-12 | 4.43E-12 | 5.376294 | |
| 6.76E-14 | 1.92E-13 | 1.95E-13 | 8.66E-14 | 1.05E-13 | 1.31E-13 | 1.14E-13 | 1.10E-13 | 1.08E-13 | 1.07E-13 | 1.06E-13 | 1.05E-13 | 1.05E-13 | 3.492889 | |
| 6.07E-13 | 2.83E-13 | 2.91E-13 | 2.98E-13 | 2.32E-13 | 2.89E-13 | 2.71E-13 | 2.60E-13 | 2.63E-13 | 2.60E-13 | 2.59E-13 | 2.58E-13 | 2.58E-13 | 8.048889 | |
| 1.71E-13 | 1.39E-13 | 1.60E-13 | 5.04E-14 | 1.30E-13 | 9.92E-14 | 9.70E-14 | 9.98E-14 | 9.70E-14 | 9.72E-14 | 9.71E-14 | 9.67E-14 | 9.66E-14 | 7.472884 | |
| 2.74E-13 | 2.85E-14 | 7.17E-14 | 1.40E-13 | 3.66E-14 | 7.96E-14 | 5.50E-14 | 5.34E-14 | 5.03E-14 | 4.72E-14 | 4.50E-14 | 4.36E-14 | 4.27E-14 | 8.345857 | h.beta |
| 1.20E-14 | 2.43E-14 | 1.75E-14 | 3.95E-14 | 1.12E-14 | 1.15E-14 | 1.11E-14 | 7.33E-15 | 6.33E-15 | 5.43E-15 | 4.53E-15 | 3.96E-15 | 3.61E-15 | 0.135347 | |
| 1.06E-13 | 2.50E-13 | 9.72E-14 | 1.49E-13 | 1.17E-13 | 9.29E-14 | 9.88E-14 | 9.63E-14 | 9.10E-14 | 8.75E-14 | 8.51E-14 | 8.33E-14 | 8.22E-14 | 3.58E-08 | |
| 6.65E-14 | 1.07E-14 | 5.18E-16 | 3.86E-15 | 9.01E-16 | 2.90E-16 | 3.66E-16 | 4.16E-16 | 4.36E-16 | 4.39E-16 | 4.32E-16 | 4.32E-16 | 4.36E-16 | 19.28682 | |
| 5.40E-13 | 1.18E-13 | 2.09E-13 | 2.15E-13 | 2.06E-13 | 1.95E-13 | 1.95E-13 | 1.93E-13 | 1.90E-13 | 1.90E-13 | 1.89E-13 | 1.88E-13 | 1.87E-13 | 3.176176 | |
| 6.08E-14 | 1.64E-14 | 1.98E-14 | 1.33E-14 | 1.08E-14 | 1.59E-14 | 1.26E-14 | 1.26E-14 | 1.19E-14 | 1.23E-14 | 1.21E-14 | 1.21E-14 | 1.20E-14 | 4.039111 | l.alpha |
| 5.04E-13 | 3.51E-13 | 2.40E-13 | 2.99E-13 | 2.58E-13 | 2.95E-13 | 2.76E-13 | 2.69E-13 | 2.71E-13 | 2.68E-13 | 2.67E-13 | 2.66E-13 | 2.66E-13 | 2.745778 | |
| 1.34E-13 | 1.46E-13 | 1.13E-13 | 1.15E-13 | 1.28E-13 | 1.02E-13 | 9.54E-14 | 9.38E-14 | 8.59E-14 | 8.32E-14 | 7.99E-14 | 7.76E-14 | 7.63E-14 | 1.959896 | |
| 2.70E-14 | 8.96E-14 | 5.22E-14 | 8.86E-14 | 7.66E-14 | 6.82E-14 | 6.68E-14 | 6.32E-14 | 5.93E-14 | 5.89E-14 | 5.74E-14 | 5.64E-14 | 5.58E-14 | 1.489582 | |
| 3.98E-13 | 2.72E-13 | 2.49E-13 | 1.94E-13 | 2.33E-13 | 2.26E-13 | 2.17E-13 | 2.16E-13 | 2.16E-13 | 2.13E-13 | 2.12E-13 | 2.11E-13 | 2.11E-13 | 0.05145 | |
| 3.02E-14 | 1.51E-13 | 1.56E-13 | 7.03E-14 | 7.06E-14 | 7.93E-14 | 5.49E-14 | 5.00E-14 | 4.17E-14 | 3.79E-14 | 3.34E-14 | 3.04E-14 | 2.86E-14 | 4.13E-08 | |
| 1.39E-13 | 1.63E-13 | 5.48E-14 | 6.29E-14 | 4.05E-14 | 4.78E-14 | 2.84E-14 | 2.18E-14 | 1.57E-14 | 1.01E-14 | 6.09E-15 | 3.15E-15 | 1.40E-15 | 43.95118 | |
| 8.18E-14 | 3.39E-13 | 9.78E-14 | 5.71E-14 | 9.30E-14 | 5.86E-14 | 4.80E-14 | 3.54E-14 | 2.31E-14 | 1.55E-14 | 8.55E-15 | 3.81E-15 | 9.75E-16 | 4.448182 | theta |

**Fig. 10.** The right most column is the final calculated value for the comedy movie (Thillu Mullu), and it is observed that alpha waves are observed mostly along with beta waves, indicating that viewer is mostly engaged and in an anti-depressed state (happy).

## 4 Conclusion

In this article, a new statistical approach to study the emotions in brain was explored for measuring the viewer's brain activity and observing patterns for an effective output. This paper proposes that latest EEG devices like Neurosky Mindwave Mobile (used in this experiment), can offer a cheaper and more affordable means for analyzing emotions effectively and easily. This study does not claim that it is the central measure to analyze emotions, and the experiment has been done, only to analyze the emotions among Indian Film viewers. The emotions of two different viewers for two different genres of Indian films - Comedy and Horror, were successfully captured and analyzed, and the results have matched with the intended emotions (which was determined based on the released movie's IMDb reviews), making this experiment a success.

## 5 Future Works

In the field of Neurocinematic studies, research could pave the way to huge developments, since it is still in its nascent stages. While one method has been explored here, for measuring the volunteers' activities in brain, there are also advancements in the field of fMRI which offer good analysis of various emotions displayed by the viewer. There are also better EEG devices with higher costs which provide near-accurate brainwave analysis. All these studies together might provide a breakthrough in accurate emotion analysis. An advanced version of this experiment, analyzing the emotions of viewers among different age groups, for all genre of films, for a longer duration could open the scope for newer reviewing techniques for movies using EEG, but as of now, this is beyond the scope of this experiment.

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