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Higuchi Fractal Dimension Analysis of EEG Signal before and after OM Chanting to Observe Overall Effect on Brain

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Article Info	ABSTRACT
	The OM chanting is one type of the meditation. In the present paper, the author tried to observe its effect on the brain. To obtain insight of the brain, the author recorded EEG signal before and after OM chanting for 10 subjects. Author used a technique of the complexity measure based on fractal analysis to compare the EEG signal before and after OM chanting. Time domain fractal dimension was calculated using Higuchi algorithm. (HFD). Paper present the results based on average HFD all over the electrodes for each subject before and after OM chanting.

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1. INTRODUCTION

Our attentiveness and concentration are pilfered from us by the things taking place around us in the world in recent times [1]. Different challenges and impediments are faced by the people working in the industries. It is tough to handle the stress sometimes. Therefore, to come out of the aforementioned troubles, different ways are available. These ways are guided meditation, Matra or transcendental meditation, mindful meditation, yoga, prayer, deep breathing, exercise.Today interest in health consciousness is attracting people to earn better health in body and contentment in mind. Yoga is a natural way to achieve good health and happiness. Meditation is one part of yoga. In the direction of mediating human subject, 'OM' is a spiritual mantra, outstanding to fetch peace and calm. The entire psychological pressure and worldly thoughts are taken away by the chanting of OM mantra.

Numerous studies have been carried out on meditation and OM chanting. In study [1], neuroelectric and imaging studies of meditation are reviewed. Basarika and Bramari are part of the pranayama. Patil et.al [2] investigated change of Correlation dimension, Largest lyapunovexponent, Approximate entropy and coherence values of EEG signal of a person under these Basarika. They found statistically significant differences in values before and after Basarika and Bramari. From their result complexity decreases after Basarika is confirmed with values of all parameters. Same results are observed for Bhramari pranayama [3]. Dr. Ajay Gurjar [1-5] carried out analysis of the acoustic of "OM" signal .By this analysis he concluded that OM therefore serves as a brain stabilizer, which is also an energy medicine for human being under stress. Shirley Telles et al [6] got very fascinating results after mentally chanting OM In this paper the autonomic and respiratory variables were studied in seven experienced meditators. The variables are heart rate, respiratory rate, skin resistance, finger plethysmogram, amplitude. The meditators showed a statistically significant positive result in all variables.

Work carried on the meditation of OM by Sanjay Kumar et al [7] showed the mental repetition of *OM* results in physiological alertness, and increased sensitivity to sensory transmission. Francois B et al

[8] carried out work on Bramari pranayama. For the first time, paroxysmal gamma waves (PGW) were observed in eight subjects practicing the yoga technique of breathing control called Bhramari. After this there is an increase theta range activity. The brain is much more complicated organ of the human body than any other part that controls body activities, ranging from heart rate, sexual functions to emotion, learning and memory. EEG is used to measure scalp potential generated due to above activities. All the above mentioned researches only effect of metal OM chanting, Bhramari and Basarika pranayama. Till date effect of OM chanting on the brain is not revealed which encouraged me to analyze EEG signal before and after OM chanting. The plan of this paper is to compare the complexity of EEG signal before and after OM chanting. The techniques such as Lyapunov exponents and correlation dimension, fractal dimension etc. can describe the complexity of an EEG data. The only parameter used for the study was Fractal dimension.

2.   MATERIAL AND METHOD

2.1 Subjects
        Eight healthy boys and girls of age between 21 to 22 and two females of age between 40 to 41 including author herself participated in this research study as subjects. Few subjects had no background of pranayama. Such 10 subjects were collected for analysis.

2.2 EEG Recording
        EEG recording was performed in an electrically shield room of Bilala hospital under the guidance of Dr. Saurabh Bilala, Akola. EEG signals were recorded according to international standard 10-20 from 18 channels using RMS India system with 256 Hz sampling frequency for bipolar montages. These electrodes are FP2-F4, F4-C4, C4-P4, P4-O2, FP1-F3, F3-C3, C3-P3, P3-O1, FP2-F8, F8-T4, T4-T6, T6-O2, FP1-F7, F7-T3, T3-T5, T5-O1, FZ-CZ, CZ-PZ (figure 1).
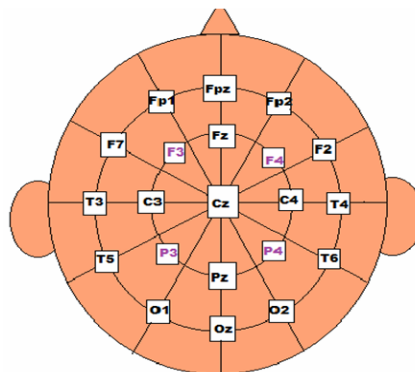

Figure 1. Electrode placement

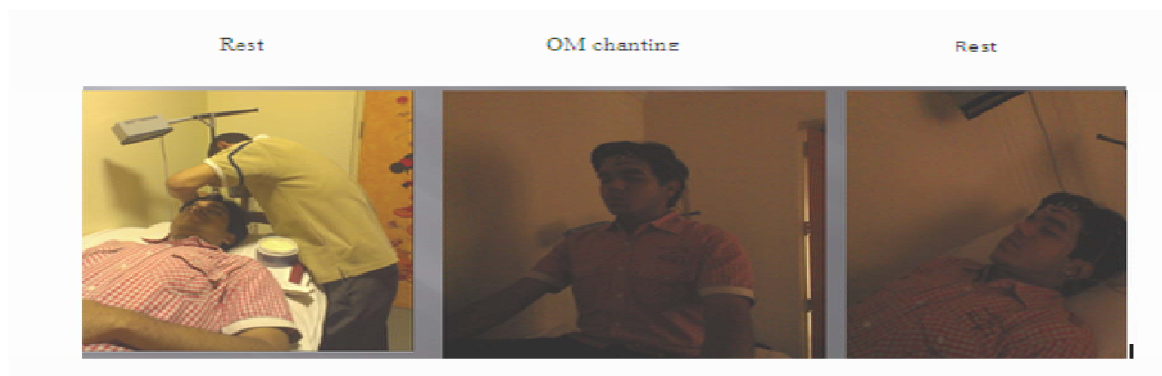For this study, following is the experimental setup.

Figure 2. Experimental setup

Figure 2 shows experimental setup. At the very first moment subject was asked to relax just laying down and with eyes closed. During which EEG of the respective subject for more than two minutes was recorded. This recorded new data is an EEG signal before OM chanting. After recording first date, subject was asked to sit down in relax state with erect posture and closed eyes and were asked to chant OM mantra for as much time as they want. While chanting OM mantra, first we have to inhale smoothly and hold the breath; soon we have to release the air (exhale) by chanting OM. During chanting by respective subject, there were no light in room.Enviorment was made silent in order to maintain calm and peace which helped subject to concentrate fully on OM chanting. Again respective subject were asked to relax by laying down and eyes were closed. EEG was recorded for more than two minutes. This recorded data is an EEG signal after OM chanting. The recording was started after 12:00 PM at noon without lunch. The complete process of EEG recording of all subjects last for five to six hours on the same day.

2.3 Higuchi Fractal Dimension

In this approach, the author applied one-fractal dimension algorithms for feature extraction, namely Higuchi (Higuchi, 1988) as follows [9]. Author used this method as it is widespread in the EEG scientific literature and that will facilitate the comparison of our results.

We now consider a finite set of time series observations taken at regular intervals.

$$X(1), X(2), X(3),......., X(N)$$

For given time series, we first construct a new time series, X_k^m, defined as follows:

$$X_k^m; X(m), X(m+k), X(m+2k),....., X(m+[\frac{N-m}{k}].k)$$

$$(m = 1, 2,.....k)$$

Where [ ] denotes the Gauss' notation and both k and m are integers and k indicate the initial time and interval time, respectively. For a time interval equal to k, we get k sets of new time series. In the case of k=3 and N=100, three time series obtained by above process are described as follows:

$$X_3^1; X(1), X(4), X(7),........, X(100)$$

$$X_3^2; X(2), X(5), X(8),........, X(98)$$

$$X_3^3; X(3), X(6), X(9),........, X(99)$$

We define the length of the curve, X_k^m as follows

$$L_m(k) = \{ (\sum_{i=1}^{[\frac{N-m}{k}]} | X(m+ik) - X(m+(i-1).k) |) \frac{N-1}{[\frac{N-m}{k}].k} \} / k$$

The term, $\dfrac{N-1}{[\frac{N-m}{k}].k}$ represent the normalization factor for the curve length of subset time series. We define length of curve for the interval k, <L (k) >, as the average value over k sets of $L_m(k)$

$$L(k) = \sum_{m=1}^{k} L_m(k)$$

If $< L(k) > \alpha k^{-D}$, then the curve is fractal with the dimension D.

The reliability of the Higuchi algorithm was tested with synthetic signal ranged from 1.001 to 1.099 using Weierstrass functions with known FD. Synthetic data was produced using determistic Weierstrass cosine function given as follows:

$$W_H(t) = \sum_{i=0}^{M} \gamma^{-iH} \cos(2\pi\gamma^i t)$$

$$0 < H < 1$$

$$\gamma > 1$$

$$\gamma = 5$$

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H—the Hausdorff dimension and we fixed = 5 and M = 26. The fractal dimension of this signal is given by D equals 2-H.

Figure 3 shows two sequences generated fromWeierstrass cosine function with known fractal dimension values [10, 11].
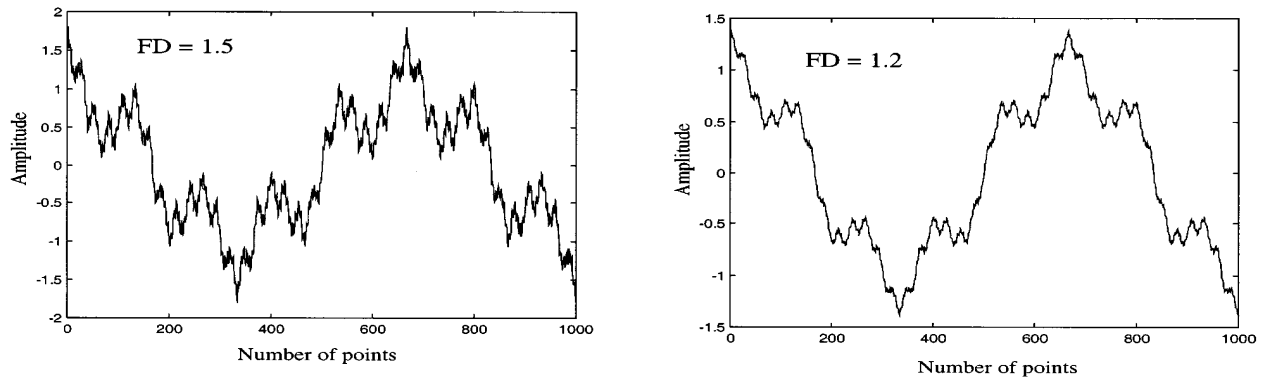

Figure 3. Weierstrass cosine function for FDs equal to 1.5 and 1.2.

2.4. Description of Comparison of EEG Signal before and after OM Chanting based on FD

In first step of our approach, epochs of 30 second duration were selected from EEG recordings of each subject immediately before and after OM chanting. This epoch was filtered by a 0.5-35Hz band pass filter since the alpha, theta, beta, delta, and gamma waves of EEG lie in this band and it is artefact free. After filtering sliding window approach was employed for calculating Higuchi fractal dimension (HFD). 200 point window with no overlap was used to promote stationary, considering that our EEG were sampled at 256 Hz. In Higuchi algorithm, there is need to choose value of kmax. Criteria for selection of this value is presented [12-14]. In order to choose an appropriate value of parameter kmax, HFD values of all synthetic signal with sliding window of 200 points was calculated.HFD values were plotted against a range of kmax for various window length. Figure 4 shows variation of HFD with kmax and window length = 200.

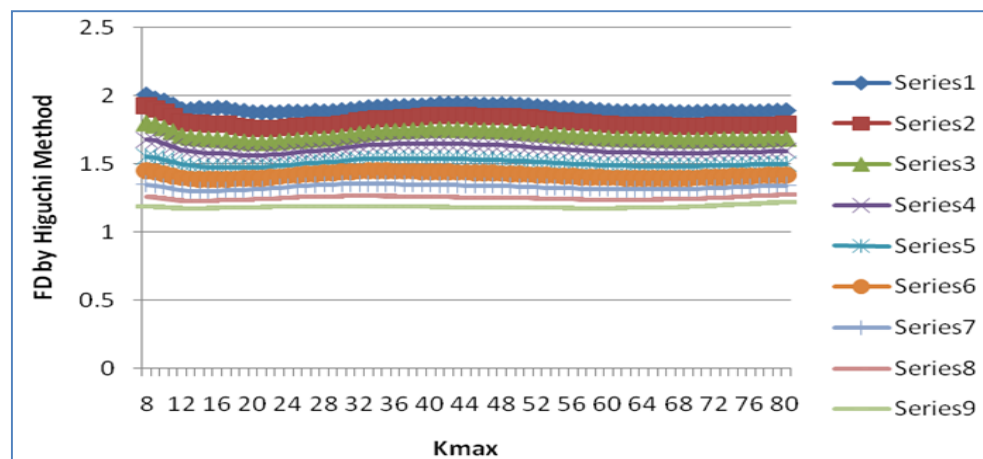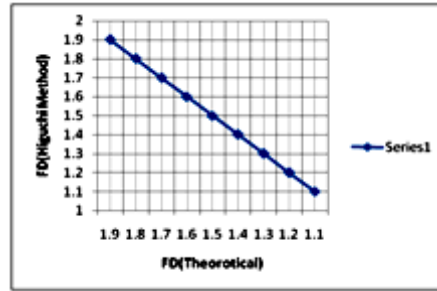Figure 4. Variation of FD of synthetic signal with kmax

Figure 5. Reproduction of FD of synthetic signal by Higuchi Method

Approximately point kmax = 60, there is no variation of HFD after this. This is a saturation point and a value of kmax=60 was chosen for our study. For kmax=60, there is perfect reproduction of FD of synthetic signal by Higuchi algorithm. This is shown in figure 5. There is one HFD for each window of 200 points. The HFD results were averaged over 30 second epochs for each electrode. The average HFD (AHFD) all over 18 electrodes is used for comparison. The method for comparison of EEG signal before and after OM chanting is shown in figure 6

Table1. Results of average HFD (AHFD) for 10 subjects

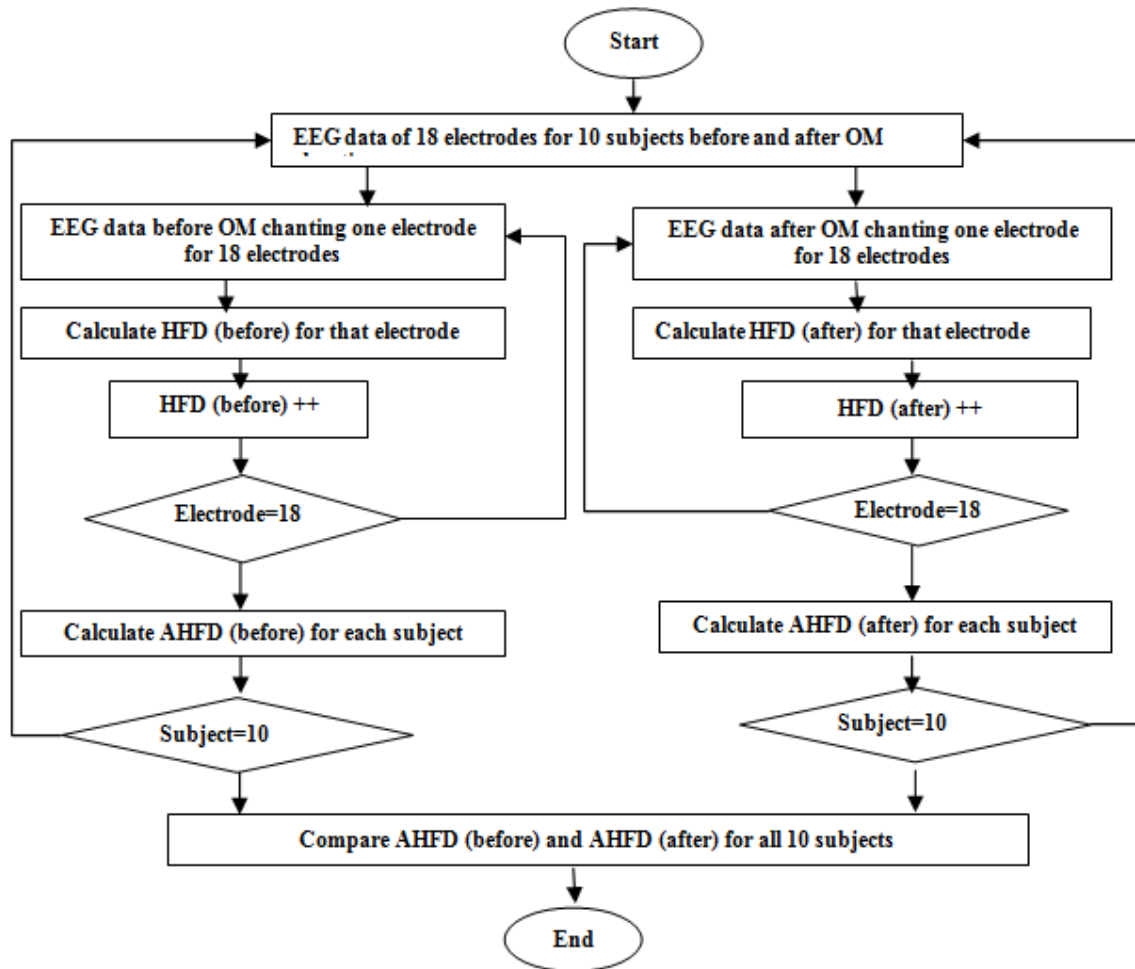|	AHFD (Before)	AHFD (After)
Subject-1	1.725574	1.721251
Subject-2	1.735015	1.704599
Subject-3	1.742036	1.72518
Subject-4	1.620742	1.500273
Subject-5	1.726386	1.690096
Subject-6	1.585519	1. 621249
Subject-7	1.675157	1.633895
Subject-8	1.628434	1.563626
Subject-9	1.704136	1.514942
Subject-10	1.700201	1.689446

Figure 6. Flowchart shows comparison of HFD before and after OM chanting to observe overall effect on brain.
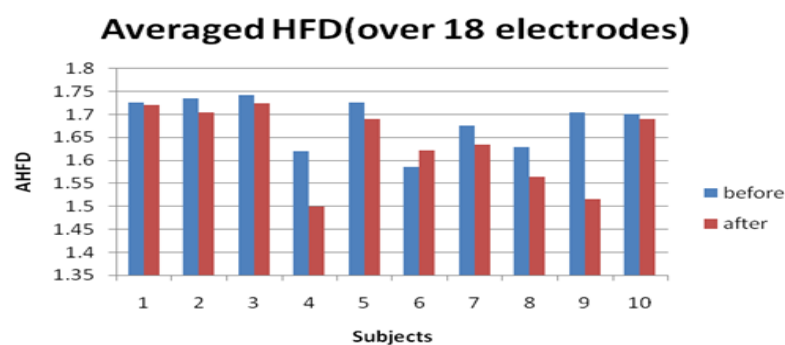

Figure 7. Bar graph shows AHFD before and after OM chanting.

3.   RESULTS

After testing the reliability of Higuchi algorithm, it was applied to EEG signal at each electrode. The average HFD value for each subject before and after OM chanting is shown figure 7. These figures revealed that a AHFD is decreasing for all 10 subjects except subject 6 after OM chanting. Table 1 shows average HFD for 10 subjects.

4. DISCUSSIONS

The fractal dimension of any signal has an inverse relation to the complexity of that signal. [12]. Decrease in HFD (AHFD) in nine subjects demonstrate that the complexity of EEG signal decreases after OM chanting but not in subject 6. All nine subjects subjectively reported only a feeling of peacefulness after completing OM chanting. These feelings of all nine subjects are correlating with results in terms of fractal dimension obtained in this paper.

But negative result was found in subject 6. That subject 6 was the author herself. The two main possible interpretations of this result in the case of author are as follows:

1) After looking back, the author found that concentration could not be achieved while OM chanting. Author was continuously busy in experiment and worried about the results. This might be one of the reasons for not getting results in that subject.

2) In addition, the present investigation reports the result on basis of AHFD which was calculated all over the brain. The different parts of the brain are affected by that mind states. Due to mind state of author, one or more than it might have been affected largely as compared to the remaining subjects. This could be another reason for hampering result only in one subject. In future work, it needs to investigate the effect of OM chanting on each and every part of the brain.

Author cannot find comparisons of our results with previous reports specific to OM chanting, as to the best of our knowledge no previous scientific investigation of this technique using EEG has been published.

5. CONCLUSION

We conclude that result obtained from analysis of EEG signal on the basis of fractal dimension can be used for diagnosis and monitoring various mind states. When you feel tired and emotionally disturbed, first you should relax yourself and chant OM fifty times or more than it by concentrating on it and you will be definitely beneficial for relaxing your mind.

6. FUTURE SCOPE

The results obtained are very encouraging where only one single feature was used in this study. This analysis can be extended in time domain for other parameters like correlation dimension, approximate entropy, largest Lyapunov exponent, the Hurst exponent. These results are for OM chanting for one day only. Further research is underway to study the performance of this feature if subject practicing OM chanting from long time.

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