Grenze International Journal of Engineering and Technology, June Issue

Early Prediction and Healing Assessment of Neuronal Disorder in Autism using a Non-Linear EEG basis Model and Bio-Energetic Correlation During Raga Therapy

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***Abstract*— In this study, 24 children with Autism Spectrum Disorder (ASD) were subjected to an EEG and Bio-Well reading before and after listening to three Carnatic ragas namely Hamsadhwani, Shankarabharanam and Bhairavi. To capture chaotic EEG features, three features were extracted based on non-linear EEG: sample entropy, Lyapunov exponents and fractal dimension. What is traditionally overlooked by conventional spectral analysis, is the neural dynamics. Complementary measures such as stress indices, chakra alignment percentages and organ energy distribution were provided by Bio-Well electrophotonic imaging. After the raga sessions, we watched Lowered EEG entropy in all frontal and temporal leads, lower Lyapunov exponents (r Results show a significant decrease in the stress index (p ¡ 0.72, p ¡ 0.01), improvement in chakra alignment metrics. The A correlation between non-linear EEG changes and bio-energetic improvements supports a possible link between the two. neuro-energetic model of therapy response. The results suggest that the suggested combined nonlinear EEG and Bio-Well assessment could be used as objective monitoring tools for tracking sleep apnea in children. Therapy for ASD.**

***Keywords*— Autism Spectrum Disorder, Non-linear EEG, Bio-Well, Neuro-energetic Cou-pling.**

I. INTRODUCTION

ASD impacts many areas of functioning such as communication, social interaction and sensory processing [1]. Recent estimates from around the world suggest that 1 out of 100 of children might be affected, However, rates are significantly higher in some areas [2]. For an unknown reason, The age range of 6 to 10 seems particularly important for the intervention – the brain is malleable and sensitive to organised sensory stimulation [3]. This is the type of study we under-took. Twenty-four children were recruited for the age window with a confirmed ASD diagnosis. What do EEG So, what do recordings tell us about autistic brains? Several investigations have converged on the conclusion that abnormal firing of neurons is the cause. ASD is characterized by abnormal oscillatory behavior, disrupted connectivity, and patterns [4]. These neural These differences appear as disruptions in the rhythms, changes in coherence values, and instability in the synchronization among different regions of the cortex [5, 6]. Changes are revealed by classical spectral analysis. In alpha, beta, theta and gamma band activities.

Grenze ID: 01.GIJET.12.2.19_25

The problem is, however, that such linear methods: Are not able to fully describe the burst-like, irregular and sometimes chaotic patterns that can be observed in ASD. electrophysiology [7, 8]. As a consequence, autism researchers have turned to more non-linear and chaos-based analytical methods. There are methods that have been successfully applied to quantitative measures such as sample entropy, approximate entropy, correlation dimension, Hurst exponent, and Lyapunov exponents. These were applied to describe irregularity and predictability features in neural signals [9, 10]. These metrics consistently show that EEG of ASD patients has decreased stability and increased Significantly different than the classical recordings of neurotypicals [11, 22]. In addition to elec-trical activity measurements, autonomic and bio-energetic aspects are also crucial. Important roles in ASD pathophysiology. Children with a spectrum of autism often display characteris-tics of: Sympathetic nervous system overactivity, decreased vagal tone, and impaired ability to recover from stress [12, 13]. Based on Gas Discharge Visualization (GDV) technology, Bio-Well electrophotonic imaging offers an indirect approach of assessing such states by analysing. Controlled stimulation of the fingertips to produce emission patterns of photons [14, 15]. Music interventions have been thought to be valuable complementary treatment for autism for a long time. Indian classical Raga Therapy has gained special research interest due to ragas, consist of carefully designed sequences of swaras (musical notes), intervals, and characteristic phrases that are generally linked to emotional and physiological effects [16, 17]. Ragas like Ham-sadhwani are linked with alertness and attention enhancement; Shankarabharanam is linked to emotional equilibrium and stability; Bhairavi is linked to calming effects. and parasympathetic activation [18, 19]. While being able to synchronously record EEG and autonomic proxies, as well as energetic, is uncommon in current ASD research. Imaging in integrated computa-tional paradigms. In general, the various modalities are given one at a time. analysis—EEG for cortical dynamics, physiological measures for autonomic nervous system While the functional scales for assessing behavior and the subjective scales for assessing function are also included. This separation makes it difficult to understand the interaction between the changes in each do-main. As such, the current study, This is addressed by a non-linear EEG basis model for ASD, which is particularly designed for this purpose.

II. Literature Review

A. EEG Abnormalities in Autism

What is the literature on the EEG literature telling us about autism? The possibility of altered is suggested by multiple investigations. Some of the oscillatory dynamics and disrupted connec-tivity [4]. In particular, a decrease in alpha coherence, abnormal theta modulation and higher beta/gamma activity have been reported. These EEG markers relate to clinical features such as attention problems, sensory filtering They include cognitive issues, and problems [4, 6]. The results here are consistent with a more general view of ASD as a disorder of long-range cor-tical networks [7]. Although linear spectral analysis is useful, it is still deficient in describing the Properly account for the non-stationary nature of autistic EEG does not use the technique. Model unusual, temporary actions [8]. To overcome these drawbacks nonlinear descriptors are introduced in literature. Initial conditions by measuring the rate at which orbits of nearby initial conditions diverge from initial conditions; the ‘randomness level’ is measured by ”entropy”; fractal dimension The geometrical complexity of brain signals is captured by estimates [9, 10, 20]. Multiple studies have showed children with ASD to have higher entropy values and dif-ferent fractal features than controls, which was interpreted as an increase in neural noise in children with ASD. and resulted in less system stability [21–23]. Most of the approaches cur-rently available, however, consider the non-linear indices as static attributes and not part of an evolving model which can monitor changes throughout. therapeutic interventions.

B. Autonomic Dysregulation and Bio-Well Assessment

What is consistently being found in autism research? Disorders of the body’s automatic func-tions. Scientists see it again and again. Not only social issues but also concealed rhythms of the body misalign. Found in numerous papers. Body control problem is a continuous theme throughout the findings. When signals of calm diminish and fears increase, the bodies tend to move. There’s a lot of that on display during stressful times. Chronic stress can accumulate over time, leading to more tips towards reaction than rest. It is more difficult to regulate emotions [11,24]. Bio-Well Other ways based on Gas Discharge Imaging have come up as possible tools that can gathering overall data on tension and energy flow [14, 15, 25]. Despite this, there is still debate about the significance of these numbers in living systems. scientific community, re-lationships to HRV and other well-known physiological parameters. Signs show up now. Those links suggest these actions could be used in conjunction with: Body signals stand Fewer or inhibited automatic nervous system activities and mood changes [26].

C. Music Therapy and Raga Interventions

Research has been conducted through a number of systematic reviews on the effects of music therapy on autistic people, and findings indicate improvements in the communication and bond-ing aspects of music. These results are found in the reviews of several studies [27]. Gains are typically seen when a person interacts. How well someone can pay attention, hear words, how well they understand words they hear, during shared activities In addition to their involvement, their level of engagement. Using a brain science perspective on physical therapy, Logically, music could alter brainwave patterns and activate activity in the brain as well. the emotional centers of the brain along with automatic body reactions [28, 29]. Out of ancient Evidence - ra-gas from classical music in India are associated with healing.Classical music from India, ragas have long been associated with healing - traditions comes evidence. Some tunes that have been influenced by time were found to be promising to connect with health practices. This is because they help to regulate the body's functions, such as sleep and blood pressure, etc. There is some research examining connections between size-related setups and feelings [19, 30]. In real world applications, these Old beliefs are being tested by monitoring body and mind changes while working in them. Despite this, there have been definite patterns that have emerged, connect-ing brainwave information to bodily responses. slowly. However, the relationship between the patterns of electrical activity and physical changes is more complicated. There's been a bit of improvement recently. Despite this, there are ways to match real-time nervous system Careful work is required for shifts with neural signals. Some of the links demonstrate potential when studied closely. observation Most lively aspects still show up rarely.

D. Identified Research Gaps

Several critical gaps emerge from the reviewed literature. First, EEG non-linear measures are typically analyzed separately from therapeutic protocols, making it difficult to establish direct connections with intervention-induced changes. Second, Bio-Well and related energetic tech-niques are rarely combined with EEG recording within the same experimental framework, es-pecially for ASD populations. Third, Raga Therapy is usually evaluated using subjective scales or simple physiological metrics, without integrated models capturing how brain dynamics and energetic balance co-evolve during interventions

III. Methodology

A. Participants

Among those studied, kids ranging from age six to ten were part of the group. Twenty-four participated, all of whom had been diagnosed by a physician. They suffered from what is known as mild or moderate levels That study included ASD individuals. To diagnose it, physicians will Implemented the Children's Autism Rating Scale (CARS) and other procedures consistent with DSM-5 criteria Some were omitted in the following series of points: (CARS) [31]. Some people who had a record of Some have epilepsy and others suffer from severe vision or hearing loss. Some have severe symptoms of anger. Potential behavior problem that could interfere. These conditions may impact participation. When it comes to engagement, each one has its own challenge starting at ages when brain development is occurring. flexibility peaks, EEG recordings were taken. Younger minds have a more rapid rate of adaptation, group fit best: When being precise with the study rules, some people may benefit even then [32]

B. Experimental Protocol

Each time they had to take data, it began the same way. First of all, prior to any of this hap-pening, came the quiet part. A child was seated quietly in a dimly lit room, motionless and still. Inside that room, The special walls designed to block noise kept sounds muffled. The lights remained off on It was not intended to pay close attention to anything, though. As they sat there, the sensors were able to detect brain signals and readings of the energy field. There was no change in those opening minutes - steady rest. Then followed what followed: music started. Specific melodies played now, based on specified criteria. A slow way to form inner balance, based on old traditions. At that time, he switched to the active. listening. He played a series of three classical Indian music pieces in succession for people to listen to: high-grade headphones. During the entire session with the sounds, I estimate about 15 minutes. First came Hamsadhwani - which helps to focus and quicken the mental processes. Then Shankarabha-ranam, which generally aids in maintaining balance of feelings. Bhairavi was last played in calm states. Relaxations and comforts of the body signals. There was no discomfort as volume remained between 55 and 60 dB. After After the music, readouts of brainwaves and physiolog-ical data were taken once again. These used a precisely the same configuration as prior to any sounds started. Silence reigned, and instruments began to play. recorded what changed.

C. EEG Signal Acquisition and Preprocessing

We recorded EEG signals from fourteen scalp locations following the standard 10–20 system, one step ahead of the routine configurations. In separate sessions, researchers collected data at three different sample rates (128 Hz, then 256 Hz, then 512 Hz) for a layered analysis plan. They used a targeted 50Hz filter to remove electrical hum instead of throwing out disturbances, and ICA removed blinks and muscle twitches [34]. After cleaning, each EEG reading was a sequence in discrete time:

$$x[n] = x(nT_s), \quad T_s = \frac{1}{f_s} \tag{1}$$

f_s is the sampling frequency (128, 256, or 512 Hz) and Ts is the sampling interval.

D. Real-Time Feature Computation

Three time-domain features like peak amplitude, peak-hold values, and moving averages were computed continuously, To characterise rapid changes and local instabilities characteristic of autistic EEG.
Peak Value. The peak feature captures local maximum amplitude within a short analysis window:

$$Peak[n] = \max_{k=0}^{N-1} x[n-k] \tag{2}$$

Peak-Hold Model. The peak-hold mechanism retains high-amplitude events for specified durations:

$$PeakHold[n] = \begin{cases} Peak[n], & Peak[n] > PeakHold[n-1] \\ PeakHold[n-1], & (n - n_{peak}) < T_h f_s \\ Peak[n], & \text{otherwise} \end{cases} \tag{3}$$

where n_{peak} last known peak is at position marked by the index, and Th represents that peak's threshold level Some recordings last longer because the brain signals change. In autistic EEGs, sudden bursts pop up unannounced - sleep stirs can interrupt as well. But timing requires those changes to come at odd intervals. Erasing rough spots usually smooths out such moments. What we do instead keeps them intact by holding the highest value people, which fits well with ASD studies [35].
Moving Average. A moving average feature filters high-frequency jitter and captures local trend:

$$Avg[n] = \frac{1}{N} \sum_{k=0}^{N-1} x[n-k] \tag{4}$$

This smoothing technique allows to detect changes in the baseline of the neural activity while suppressing random physiological fluctuations [36].

E. Non-linear Basis Vector Construction

The non-linear characteristics were described by a basis vector B comprised of several chaos-related EEG measures:

$$B = [Peak, PeakHold, Avg, SampEn, \lambda, FD] \tag{5}$$

Sample entropy was calculated as:

$$SampEn(m, r, N) = -\ln \frac{A}{B} \tag{6}$$

The Lyapunov exponent was estimated using:
Fractal dimension was computed as:

$$FD = \frac{\log(N)}{\log(1/r)} \tag{8}$$

F. Bio-Well Electrophotonic Imaging

Right away, before and after the raga music played, every person had a Bio-Well scan taken. Each time, ten pictures came from fingertips during one scanning round. From those, built-in software pulled out certain data points - no guesswork involved. One piece showed how much stress appeared along with body strain markers. Another looked at where chakras sat and just how aligned they stayed. Energy patterns across organs also got mapped, alongside balance between left and right sides.

G. Neuro-Energetic Correlation Framework

The proposed correlation model links EEG features with Bio-Well measures:

$$Stress = a_1\lambda + a_2 \cdot SampEn + a_3 \cdot Var(Peak) \tag{9}$$

$$Energy = b_1 \cdot Avg + b_2 \cdot FD + b_3 \tag{10}$$

$$ChakraAlign = 100 - k \cdot Entropy_{total} \tag{11}$$

where a_1, a_2, a_3, b_1, b_2, b_3 and k are empirically determined regression coefficients.

H. Statistical Analysis

Pre-intervention and post-intervention values were compared using:

- Paired t-tests for variables demonstrating approximately normal distributions
- Wilcoxon signed-rank tests for variables deviating from normality
- Correlation analysis to examine relationships between EEG non-linear measures and Bio-Well indices

The significance threshold was specified at $p < 0.05$ unless otherwise specified.

IV. RESULTS AND DISCUSSION

A. EEG Non-Linear Dynamics: Pre- and Post-Raga Comparison

Comparing pre- and post-intervention recordings revealed three consistent changes across non-linear EEG measures.

Reduction in Neural Entropy. Midway through the analysis, shifts began appearing in brainwave patterns after people listened to ragas. Not just fewer random spikes, but a clearer rhythm took hold up front - especially near F3, F4, Fz spots on the scalp.

Before that moment, signals were messy, as previous studies had described. Then there was quieter chaos in general, with T3 through T6 zones quieting down as well. What grabbed your attention? Less noise where there used to be confusion

$$\Delta SampEn = SampEn_{post} - SampEn_{pre} < 0 \tag{12}$$

This negative change is consistent with increased signal regularity and could reflect greater attentional stability with less sensory overload [39].

Decrease in Lyapunov Exponent.Evidence is pointing in that direction [20, 38]: brain activity after treatment showed less randomness, more order.

Increase in Fractal Dimension.After listening to raga music, the numbers measuring com-plexity shifted in noticeable ways:

$$\bar{r} = 0.72, \qquad p < 0.01 \tag{13}$$

After hearing raga music, the complexity measures changed in important ways:

B. Time-Domain EEG Feature Analysis

Prior to treatment, sharp spikes occurred frequently and signal strength jumped around without a clear pattern. There were far fewer of those sudden peaks with Raga Therapy. The signals stayed at steadier levels – fewer wild swings, a more solid beat [35, 37]. Signals smoothed out over time; their overall flow became more predictable after therapy ended, indicating calmer background brain behaviour, better aligned moment to moment [36].

C. Multi-Rate Model Performance

But gaps appeared when the speeds didn't match. The tweaks helped, but the timing was still rough. With each shift, new mismatches emerged. Delays were smoothed and only then pat-terns emerged. Where signals moved quickly, mistakes accumulated. But in sync it all made more sense When using curved-line descriptions, we saw clear patterns across different setups.

Unified base forms brought together cies without breaking rhythm Starting at 128 Hz and then moving up - each run showed how peak behaved when held. At 256 Hz the behaviour was still visible just before stepping again towards 512 Hz. What stood out was how the hold captured extremes each time peaks appeared Consistent performance at every sample rate level [41]

D. Bio-Well Energetic Changes

Additional scanning of patients indicated a decrease in stress levels after each visit, indicating that they are progressively getting closer to some type of defined equilibrium point in their nervous systems. It has been suggested by some researchers that maintaining a more stable and balanced nervous system yields benefits [24]. Some measurements relating to chakra energies indicated that Heart and crown chakra energies were positively affected by the practice [40]. Jitteriness in the energy system also showed a slight upward trajectory, indicating an increase over time in terms of the vitality overall. Some brain wave patterns require specific openings to function properly.

E. Neuro-Energetic Correlations

Based on the data, decreases in EEG Entropy correspond with decreases in Bio-Well Stress Scores. In addition, improvements in Chakra Alignment were related to improvements in Frac-tal Dimension Trends; therefore as Fractal Dimensions increased, so did Nervous System En-ergy because Lyapunov Exponents decreased. Finally, there is a clear decrease in the Random-ness of Brain Signals corresponding with the reduction of Stress Markers.

F. Summary of Neuro-Energetic Changes

Table I gives us the interpretations of change observed during Raga Therapy sessions.

TABLE I: QUALITATIVE SUMMARY OF NEURO-ENERGETIC CHANGES AFTER RAGA THERAPY

Parameter	Direction	Qualitative Interpretation
EEG Entropy	↓ Decrease	Reduced neural irregularity
Lyapunov Exponent	↓ Decrease	Lower chaos / instability
Peak Variability	↓ Decrease	Fewer abrupt amplitude spikes
Chakra Alignment	↑ Increase	Improved energetic balance
Stress Index	↓ Decrease	Lower physiological load
Nervous-System Energy	↑ Increase	Enhanced regulatory support
Fractal Dimension	↑ Increase	Richer, more adaptive dynamics

G. Limitations

A few shortcomings need pointing out. To start, the number of participants - just 24 - is on the small side. Next comes the missing comparison group that would have heard sounds without music elements. Then there’s the issue with the Bio-Well gadget: its hidden calculation methods block others from repeating the study exactly. Last, how long those results actually stick around remains unknown.

V. CONCLUSION

We have described a non-linear EEG modeling approach that captures the chaotic neural dy-namics characteristic of autism spectrum disorder. The proposed framework integrated peak detection, peak-hold mechanisms, and moving-average features within a multi-rate sampling scheme.

Statistical analysis of pre- and post-intervention data from twenty-four children with mild-to-moderate ASD revealed consistent reductions in EEG entropy measures, improvements in chakra alignment metrics, and decreases in stress-related indices following structured exposure to three Carnatic ragas: Hamsadhwani, Shankarabharanam, and Bhairavi.

Two implications emerge from this work. First, non-linear EEG features combined with Bio-Well measures may help track therapeutic progress in ASD. Second, the proposed frame-work could support personalized intervention selection. Still, these findings require validation in larger samples. Future studies should also examine longitudinal effects and incorporate ad-ditional physiological measures.

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