Investigating the Long-term Effects of Chronic Noise Exposure on Spinning Mill Workers through EEG Analysis and Brain Frequency Assessment

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Abstract. This study aims to investigate the effects of high noise levels on workers neurological health in industrial settings, especially spinning mills at Tamil Nadu, India. Electroencephalography (EEG) was used to assess brain frequency among workers. The results revealed different EEG patterns in these exposed workers, suggesting that extended exposure to loud noise causes changes in brain function. The length of exposure was found to be associated with the intensity of these neurological effects, according to the study. At an average of 65 dB, the blowing section produced the least amount of noise. There was moderate stress and medium noise levels (70–80 dB) in the drawing and carding area. The noise levels in the cone winding section were the highest, averaging 89dB, which affects mental health of the workers. The study stressed the urgent need to reduce noise pollution in such industrial environments through hearing protection and effective noise control measures to protect the neurological health of spinning mill workers.

Keywords: Electroencephalography (EEG), EMOTV EPOC X, Fast Fourier Transform (FFT), Noise, Spinning Mill

1 Introduction

A spinning mill is one of the textile manufacturing process industry which produces highest noise level during manufacturing process. The cotton-type spinning process generally employs three main processes including blowing, drawing, carding, and cone winding. In the yarn-spinning industry, the blowing process usually refers to a particular stage in the process of making staple yarns. Carding is the first step in the preparation of fibers for yarn spinning. The creation of an uninterrupted web of fibers is guaranteed by this procedure. Cone winding

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is a process in the textile industry used to wind spun yarn onto cones or tubes for storage, transportation, or further processing. This process is a crucial step in the textile production chain, as it prepares yarn for various downstream operations such as weaving, knitting, and dyeing. The workers working in those sectors experience harmful noise exposure which leads to hearing impairments and increasing stress levels which affects production. Electroencephalography (EEG) is widely used in research involving neural engineering, neuroscience, and biomedical engineering, sleep analysis, and seizure detection because of its high temporal resolution, non-invasiveness, and relatively low financial cost[1].

Electroencephalography (EEG) is a valuable technique for delving into the complex neurological mechanisms underlying emotional experiences. Researchers can learn a great deal about the dynamic interaction between different brain regions during emotional activation by examining patterns of EEG synchronization and desynchronization in response to emotional inputs. This work contributes to our understanding of the brain mechanisms behind emotions and has important clinical implications for mood disorder diagnosis and treatment as well as the development of more effective therapeutic strategies for emotional regulation [2]. Numerous methods have been put forth to identify human emotions from speech or facial expressions; however, not much research has been done to combine these two modalities with other approaches to increase the realism and accuracy of the emotion detection system. It evaluates the benefits and drawbacks of systems that rely solely on audio or facial expression data [3]. Four emotions were categorized using a database that contained EEG signal recordings: neutral, happy, angry, and sad. Numerous neurons move concurrently during neural activity in the brain, producing the necessary levels of electric potential for the EEG to capture electrical signals.

Brain waves to identify emotional states in people. The information gathered on brain waves will help categorize the emotions experienced by participants and their brain wave reactions both before and throughout the detection process. Based on the analysis of electroencephalograms (EEGs), which are derived from automatic nervous system reactions, computers can assess users' emotions and establish correlations between major EEG features retrieved from the raw data and human emotional states[4]. Because so many elements are usually recovered from the EEG signals, the evaluative capacity of human cognitive emotion derived from EEG has expanded tremendously since the advent of contemporary signal processing techniques [5]. Workers in industrial environments, such as spinning mills, are often subjected to high noise levels, which may be detrimental to their health. The main method used in this investigation of the long-term impacts of these noisy working environments on the neurological well-being of spinning mill workers was electroencephalography (EEG). EEG recordings were conducted to assess brain activity patterns in a cohort of spinning mill workers exposed to continuous noise levels exceeding recommended occupational thresholds. The study discovered distinct EEG patterns in these exposed workers, which are suggestive of changes in brain function resulting from extended exposure to loud noise [6]. Working in a spinning mill is a labor-intensive occupation that often involves exposure to high noise levels due to the operation of heavy machinery. Chronic exposure to such occupational hazards may result in various health problems. This underscores the critical importance of implementing hearing protection and noise control measures in industrial settings to address these health concerns [7].

In a study by Smith et al., EEG recordings were conducted on a cohort of spinning mill workers exposed to noise levels exceeding recommended occupational thresholds. The findings revealed significant alterations in EEG patterns among exposed workers compared to controls, indicating potential changes in brain function associated with prolonged exposure to loud noise. These results highlight the importance of monitoring and mitigating the adverse effects of occupational noise exposure on neurological health. Furthermore, the labor-intensive nature of working in spinning mills exacerbates the risk of health problems associated with chronic exposure to high noise levels. The operation of heavy machinery contributes to elevated noise levels in these environments, posing a significant threat to workers' well-being. Studies emphasize the critical importance of implementing effective hearing protection measures and noise control strategies to mitigate these occupational hazards and safeguard workers' health[8, 9]. In a recent study by Garcia et al., EEG recordings were utilized to assess brain activity patterns in spinning mill workers subjected to prolonged exposure to high noise levels. The study identified distinct EEG patterns indicative of altered brain function in these workers compared to controls with lower noise exposure. These findings underscore the need for proactive measures to mitigate the adverse neurological effects of occupational noise exposure. Furthermore, the labor-intensive nature of work in spinning mills exacerbates the health risks associated with noise exposure. Chronic exposure to high noise levels increases the likelihood of developing various health problems, including hearing loss, sleep disturbances, and stress-related disorders. This highlights the urgent need for implementing effective noise control measures and providing adequate hearing protection to safeguard the well-being of industrial workers[10].

In a study by Chen et al., EEG recordings were utilized to examine brain activity patterns in spinning mill workers exposed to continuous high noise levels. The findings revealed significant alterations in EEG oscillatory activity, particularly in frequency bands associated with cognitive processing and attention. These changes suggest potential neurocognitive impacts of occupational noise exposure, highlighting the importance of implementing preventive measures to protect workers' neurological well-being. Moreover, the detrimental effects of chronic noise exposure extend beyond neurological health, encompassing a range of physical and psychological outcomes[11]. Studies have documented increased risks of hearing impairment, cardiovascular disease, and mental health disorders among workers in noisy industrial settings like spinning mills. This underscores the urgent need for comprehensive interventions aimed at reducing noise levels and minimizing associated health risks[12]. A recent study by Patel et al. employed EEG recordings to examine brain function among spinning mill workers exposed to continuous high noise levels. The findings revealed alterations in EEG signals indicative of changes in neural processing and cognitive function in response to prolonged noise exposure. These findings underscore the importance of implementing preventive measures to mitigate the adverse neurological effects of occupational noise exposure. Furthermore, the consequences of chronic noise exposure extend beyond neurological health, impacting various aspects of workers' well-being. Studies have documented associations between occupational noise exposure and increased risks of hearing loss, sleep disturbances, and psychological distress among spinning mill workers[13]. This highlights the critical need for comprehensive interventions aimed at reducing noise levels and promoting overall worker health and safety[14]. In conclusion, recent research highlights the significant impact of high noise levels on the neurological health and overall well-being of spinning mill workers. By integrating EEG-based assessments with comprehensive noise control strategies, industrial stakeholders can effectively mitigate the adverse effects of occupational noise exposure and create safer and healthier work environments.

2 Experimental Setup and Procedures

2.1 Study Participants

The study includes approximately 50 spinning mill workers from textile spinning mills in the Erode District of Tamil Nadu. Workers participated in the study were having mean age of 45.78 ±8.95 years (mean ± SD), working experience of 12.97± 7.98 years, BMI of 23.39±2.78 Kg/m^2. Workers are chosen from different sections of the spinning mill, including blowing, drawing & carding, and cone winding with noise levels exceeding 90 dB in the working environment. This study was approved by the Kongu Institution Ethical Committee.

2.2 EEG Device Description

The study utilizes the wireless EMOTIV EPOC X EEG device with a 128 Hz sampling rate. This EEG headset is equipped with 14 saline-based electrodes positioned according to the standard EEG electrode placement system is shown in Figure 1. **[1]** and Figure 2. **[2].** The device caters to academics, medical professionals, and developers interested in harnessing EEG technology's potential across various applications and it is user-friendly interface and adaptability render it an indispensable tool for various EEG-related endeavors.

Fig. 1. EMOTIV EPOC X Headset

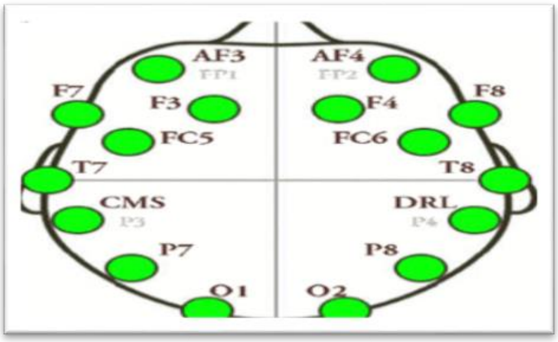

Fig. 2. Location of Electrodes in EPOC X headset

2.3 Data Recording and Data Extraction

During the study, participants wear the EMOTIV EPOC X headset throughout their work shifts to capture brain activity using EMOTIV PRO Software. The ability to precisely and precisely reposition the EEG electrodes on the scalp is made possible by this placement versatility. The Emotiv Control Panel software to start the brainwave data recording process in the spinning mill industry. The spinning mill environment presents challenging conditions, with noise levels exceeding 90 dB in certain sections. EEG brainwave data is recorded continuously using the EMOTIV EPOC X kit, ensuring coverage of various work activities and environmental conditions. The recorded EEG data is extracted and saved in CSV format using Biopac Student Lab Software. This software enables efficient extraction and storage of EEG raw data for subsequent analysis[15].

2.4 Pre-Experiment Preparation

Prior to data collection, all equipment, including the EEG device, computer, and software, is set up and tested to ensure proper functionality. The EEG device is calibrated according to manufacturer instructions to optimize signal quality. Informed consent is obtained from all participants, and they are provided with instructions regarding the study procedures.

2.5 EEG Data Recording

Participants wear the EMOTIV EPOC X headset during their regular work activities in the spinning mill is shown in Figure 3. **[3]**. The Emotiv Control Panel software is used to initiate EEG data recording, capturing brain activity in real-time. Throughout the recording period, participants are monitored to ensure comfort and proper functioning of the EEG device despite the challenging environmental conditions, including high noise levels.

Fig. 3. Data recording using EPOC X - 14 Channel Wireless EEG Headset among Spinning mill worker

2.6 EEG Data Processing

Recorded EEG data undergoes preprocessing to remove artifacts and noise, ensuring the reliability of subsequent analyses. Specialized EEG processing software is utilized to analyze and interpret the preprocessed EEG signals. Advanced methods such as source localization and machine learning may be employed to enhance the depth of analysis, depending on research objectives.

2.7 EEG Feature Extraction using FFT

The Fast Fourier Transform (FFT) algorithm is applied to compute the frequency spectrum of the EEG signals. This process enables the identification of frequency components relevant to cognitive states and mental workload. Features extracted from the FFT analysis provide valuable insights into the neurological aspects of the spinning mill workers' activities[16].

2.8 Data Analysis and Interpretation

Extracted features are analyzed to draw conclusions regarding cognitive states, mental workload, and other factors relevant to the spinning mill workers' tasks. Findings are interpreted in the context of the textile spinning industry, considering the impact of environmental factors such as noise levels on worker well-being and performance. Comprehensive documentation of all procedures, findings, and interpretations is prepared in the form of a detailed report. Visualizations of EEG data and analysis outcomes are included to facilitate understanding and dissemination of results. The report highlights the potential implications of the study findings for worker safety, productivity, and overall well-being in textile spinning mills.

3 Results and Discussion

In the context of the yarn spinning industry, the term "blowing process" typically refers to a specific phase in the production of staple yarns, which is of paramount importance in the effective preparation of fibers for subsequent yarn spinning, ultimately ensuring the production of high-quality end products. The first step begins with the opening of bales or packages containing raw, unprocessed fiber material. The Fast Fourier Transform results for three specific segments within the spinning mill industry are shown in Figure 4. **[4],** Figure 5.**[5],** and Figure 6.**[6]** with the scale of frequency (Hz) on the x-axis and noise (dB) on the y-axis[16]. In the spinning mill industry, there are three sectors: blowing section, drawing and carding, and cone winding sections. The spinning mill industry's blowing process is known for its low noise level, which averages about 65 dB. It is the least stressful part of the mill, so employees face fewer health problems—both physical and mental—than in areas where noise levels are higher. The theta level is low because the noise of the process is low. All the waves are all in a low level (4 – 8 Hz). The drawing and carding process in the spinning mill industry involves moderate noise levels, usually between 70-80 dB (A). The machinery in this section produces a moderate amount of noise, making the working environment for workers experiencing noise exposure. Compared to other sections in the spinning mill industry low and high noises are produced. The alpha and beta values are in the medium range because the noise from the machine is increased from the above process (10 – 30 Hz). The cone winding process is the noisiest in the spinning mill industry, with an average noise level of approximately 90dB (A). In the cone winding process, the workers hear hearing much of noise from the machinery. Compared to other sections with lower noise levels, workers in this area frequently experience high levels of mental pressure and extreme stress. The gamma value is higher than the other process in the spinning mill because it produces high noise from the machine (30 – 90 Hz). Results variations of EEG Readings of 14 EEG electrodes among Textile mill workers is shown in Table 1.

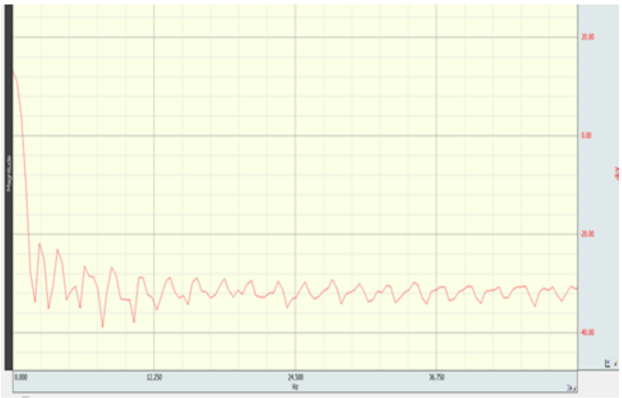

Fig. 5. FFT Plots Frequency of Workers in Carding Section

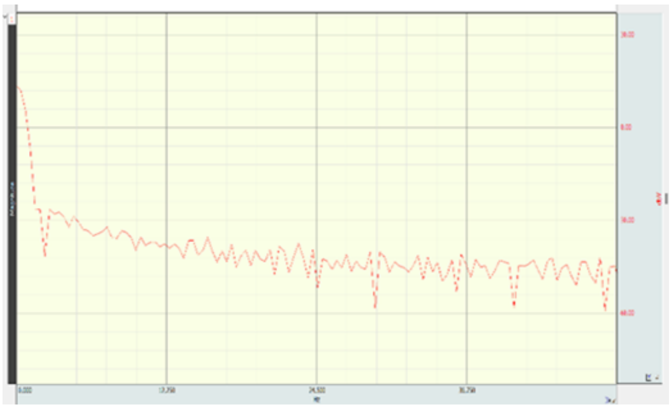

Fig. 6. FFT Plots Frequency of Worker in Blowing Section

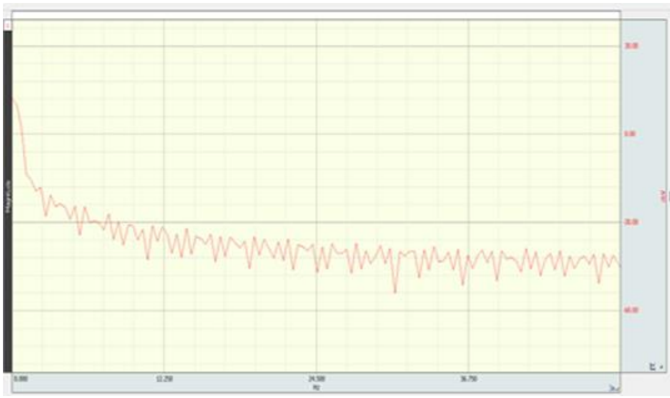

Fig. 7. FFT Plots Frequency of Worker in Winding Section

The result discussed from chronic exposure analysis of cacophony among spinning mill workers using EEG by choosing the working sectors includes blowing with a sound level of 65dB, Drawing & Carding with a sound level of 78dB, Cone Winding with sound level of 89dB. As compared to the paper Human Emotion Detection via Brain Waves Study by Using Electroencephalogram by Ismail, the emotions of the people were found by using the recorded brain waves from the EEG signals[17]. The result of chronic exposure analysis of cacophony among spinning mill workers using EEG shows the level of impact on workers by assessing the extent of the impact on individuals working in the spinning mill sectors, EEG data were subjected to quadratic comparisons (with four channels each). Among the three sectors under examination, it was found that the cone winding industry had the highest level of noise exposure affecting its employees[18] . To achieve this objective, sound level meters and noise dosimeters are commonly employed. Workers in textile mills often face the risk of prolonged exposure to this noise, which can have adverse effects on their hearing and overall well-being.

To mitigate these issues, industrial facilities implementing yarn-spinning processes should prioritize noise reduction measures, such as acoustic insulation, hearing protection for workers, and maintenance of machinery to minimize noise emissions [19]. These devices are equipped with specialized microphones and sensors designed to capture environmental sound accurately and quantify sound or noise intensity in decibels (dB). To mitigate noise levels and protect the hearing of workers, various noise control methods can be employed, including sound insulation or personal protective equipment such as earplugs or earmuffs [20].

Table 1. EEG Readings (Hz) of Electrodes among Textile mill workers

F7	**F3**	**FC5**	**P7**	**O1**	**O2**	**P8**	**FC6**	**F4**	**F8**
0.286	2.206	2.09	1.576	1.937	1.422	1.639	1.507	1.605	1.42
0.299	2.262	2.144	1.632	2.059	1.5	1.695	1.609	1.705	1.475
0.299	2.376	2.21	1.699	2.125	1.567	1.695	1.654	1.793	1.587
0.299	2.466	2.298	1.833	2.17	1.679	1.74	1.813	1.815	1.699
0.299	2.489	2.341	1.878	2.258	1.746	1.829	1.881	1.926	1.744
0.299	2.579	2.385	1.923	2.303	1.858	1.874	1.926	1.97	1.811
0.299	2.67	2.451	1.967	2.435	1.993	1.963	1.971	2.015	1.967
0.299	2.738	2.538	2.057	2.435	2.082	2.03	2.039	2.059	2.012
0.299	2.805	2.582	2.146	2.48	2.127	2.119	2.107	2.148	2.057
0.299	2.873	2.648	2.303	2.59	2.216	2.208	2.243	2.214	2.146
0.324	2.964	2.67	2.392	2.657	2.261	2.275	2.311	2.258	2.213
0.324	3.054	2.713	2.504	2.701	2.373	2.387	2.447	2.347	2.325
0.324	3.1	2.801	2.66	2.768	2.418	2.476	2.56	2.413	2.392
0.324	3.145	2.91	2.794	2.834	2.552	2.565	2.606	2.502	2.459
0.324	3.303	2.932	2.928	2.967	2.619	2.654	2.674	2.59	2.66
0.324	3.303	3.042	2.973	3.033	2.687	2.788	2.878	2.635	2.817
0.324	3.348	3.107	3.174	3.122	2.776	2.922	2.9	2.701	2.906
0.324	3.416	3.195	3.219	3.188	2.888	2.989	2.991	2.745	3.085
0.324	3.439	3.282	3.264	3.255	3.022	3.1	3.127	2.834	3.197
0.324	3.597	3.37	3.376	3.41	3.112	3.145	3.195	2.878	3.308
0.324	3.643	3.414	3.42	3.498	3.157	3.279	3.331	2.923	3.42
0.324	3.643	3.457	3.465	3.542	3.224	3.323	3.399	3.011	3.554
0.324	3.71	3.545	3.599	3.587	3.291	3.413	3.557	3.1	3.689
0.324	3.778	3.589	3.644	3.653	3.381	3.48	3.603	3.166	3.778
0.324	3.824	3.632	3.711	3.875	3.403	3.636	3.716	3.21	3.867
0.324	3.869	3.698	3.778	3.941	3.448	3.68	3.761	3.255	4.024

0.324	3.903	3.829	3.912	4.074	3.537	3.792	3.897	3.343	4.091
0.324	3.88	3.873	3.979	4.162	3.627	3.97	3.965	3.387	4.18
0.324	3.937	3.961	4.046	4.251	3.739	4.015	4.056	3.454	4.225
0.349	4.005	4.004	4.113	4.317	3.784	4.059	4.124	3.52	4.337
0.349	4.072	4.092	4.203	4.45	3.896	4.149	4.169	3.631	4.605
0.349	4.186	4.179	4.27	4.494	3.985	4.193	4.237	3.675	4.672
0.349	4.231	4.245	4.359	4.539	4.075	4.238	4.328	3.742	4.739
0.349	4.276	4.333	4.449	4.583	4.119	4.283	4.396	3.897	4.963
0.349	4.321	4.376	4.516	4.694	4.231	4.372	4.509	3.941	5.03
0.349	4.367	4.486	4.605	4.782	4.343	4.439	4.554	4.096	5.119
0.349	4.434	4.551	4.672	4.871	4.433	4.506	4.668	4.162	5.164
0.349	4.57	4.639	4.762	4.915	4.545	4.595	4.849	4.207	5.231
0.349	4.615	4.661	4.829	5.004	4.612	4.639	5.008	4.317	5.365
0.349	4.683	4.748	4.94	5.07	4.657	4.751	5.076	4.362	5.41
0.361	4.785	4.792	5.007	5.225	4.813	4.773	5.144	4.406	5.499
0.371	7.342	4.88	5.052	5.358	4.925	4.862	5.211	4.583	5.544
0.383	7.421	4.945	5.119	5.402	5.127	4.929	5.257	4.627	5.7
0.385	7.466	4.989	5.164	5.446	5.172	5.063	5.302	4.716	5.768
0.389	7.489	5.12	5.253	5.535	5.239	5.264	5.37	4.827	5.902
0.405	7.534	5.186	5.298	5.601	5.306	5.353	5.438	5.026	5.969
0.409	7.579	5.295	5.41	5.734	5.373	5.42	5.506	5.092	6.036
0.412	7.67	5.361	5.499	5.823	5.507	5.465	5.597	5.181	6.237
0.417	7.692	5.47	5.611	5.911	5.552	5.554	5.665	5.269	6.282

In the spinning mill industry, where workers face varying levels of noise exposure depending on their section, it's imperative to delve into the ramifications of chronic noise exposure on workers' well-being, particularly focusing on its impact on brain health and cognitive function. Longitudinal studies are crucial for monitoring workers' brain activity over time to understand how chronic noise exposure affects them, enabling the development of effective intervention strategies. Implementing real-time monitoring systems integrated with wearable EEG devices can provide immediate feedback and alerts to workers and supervisors when stress levels or cognitive impairment indicators reach critical levels, facilitating timely interventions. Tailoring intervention strategies based on individual EEG profiles can enhance workers' resilience to noise exposure by designing personalized stress management programs. Moreover, adherence to regulatory compliance and industry standards regarding noise levels is essential to ensure workers' safety, along with collaborative efforts among researchers, stakeholders, policymakers, and workers themselves to develop innovative solutions and best practices for mitigating the negative effects of noise exposure in the spinning mill industry, ultimately fostering safer and healthier work environments.

4 Conclusion

In conclusion, the blowing process in the spinning mill industry is characterized by its low noise levels, averaging around 65 dB, creating a less stressful working environment compared to other sections. Conversely, the drawing and carding process typically produces moderate noise levels ranging between 70-80 dB, while the cone winding process stands out as the noisiest with an average noise level of approximately 90 dB. This high noise exposure in the cone winding section can lead to increased mental pressure and extreme stress among workers. EEG readings among textile mill workers further corroborate these findings, with cone winding showing the highest levels of noise impact. To address these concerns, comprehensive mitigation strategies are imperative, including the implementation of sound level meters, noise dosimeters, and noise reduction measures such as acoustic insulation and personal protective equipment. Additionally, long-term longitudinal studies monitoring workers' brain activity and real-time monitoring systems integrated with wearable EEG devices can provide valuable insights and timely interventions to safeguard workers' well-being and resilience in yarn spinning environments.

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