Impact of Occupational Noise on the Cognitive behavior among the Textile workers using Stroop Test - An Neuropsychological Functioning Assessment

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Abstract

Cognitive stressors are one of the major influencing factors on industrial workers' cognitive functions. The purpose of this study was to assess the neuropsychological functioning of power loom workers located in Tamil Nadu, India, with the help of the Stroop test, which measures the response, attention, and processing speed against cognitive stressors. The Stroop tests were conducted for 100 power loom workers and 25 controlled subjects with three conditions: word test, color test, and color-word test. Since the mean inference score is at -3.0, the overall cognitive performance is acceptable, even though the age and BMI of the participants have differences. The statistical study highlights that demographic variables like age and education have a significant effect on the performance of the participants. The ERP data clearly indicates that the controlled subjects have stable patterns, whereas the power loom workers have higher variations in their cognitive responses. The above results indicate the immediate interference in reducing the cognitive stressors among power loom workers to improve the general well-being and productivity by initiating cognitive training and stress management programs.

Keywords: Stroop Test; Cognitive Stressors; Power Loom Workers; Statistical Study

1. Introduction

One of the significant contributor to Indian economy is textile industry, where millions of workers are employed across India predominantly in rural and semi-urban areas contributing around 14% to industrial production [1]. The power loom industries served as transitional technology and historically played a vital role in bridging the gap between traditional handloom weaving and fully automated production [2]. The modernization in industries improve the productivity, also the workers were exposed to various occupational hazards which may negatively impact both mental and physical health [3]. The industrial and occupational workers need to maintain their performance over prolonged work shifts, under physiological stress and in acoustically stressed environment, which makes them vulnerable. Based on the recent studies the mental workload and stress substantially affects the performance and error rates of the industrial workers [4]. More than the hearing impairments, continuous noisy environment will have impact on the cognitive functions such as working memory, attention, and executive processes [5]. The Stroop Color-Word Test (SCWT) is one of the highly preferable standard tests for evaluating cognitive functions such as response, attention, and processing speed [6, 7]. Industrial noise, continuous work shifts and ergonomic strain are highly influencing factors for cognitive impairment [8, 9]. The Stroop effect showcases the intervention caused when contradictory inputs like the word 'blue' is printed in green ink will delay the reaction times due to the struggle between controlled and automatic processes. It thus offers valued insights into the efficiency of the brain managing the incongruent data. The Stroop performance is also induced by the demographic factors such as age, gender and education [10-12]. For instance, naturally the aged workers exhibit greater intervention scores and slower reaction times, which reflects the age-related cognitive impairment [13]. Correspondingly, there will be restrictive response among the individuals who have lower educational attainment [14]. This study aims to identify the performance of power loom workers in Stroop test, which will provide a greater insight into the cognitive stressors inducing the inhibition control in this vulnerable underexplored population. Furthermore, the variation in Stroop interference related to age, gender, education and noise exposure is explored among these power loom workers. From the investigation of Stroop effects with industrial health research, the findings aim to enhance the well-being of workers as well as productivity by emphasizing ergonomic improvements and cognitive training.

2. Methods

2.1 Participants

The participants were approached from 15 power looms located in Erode; Tamil Nadu included 100 participants (61 males and 39 females; mean age 44.5 ± 14.5). These participants have been filtered by their ages and body mass index (BMI) range to exclude the unhealthy participants. After these evaluations, 51 participants (12 males and 39 females) have been sorted into the means of healthy lifestyle, no significant medical or psychiatric history and educational qualification, since the Stroop test involves the reading skill. The demographic details of the 51 participants have been provided in Table 1. The participants have volunteered themselves for this research and no compensation or any other benefits have been provided to the participants. Another total of 25 controlled volunteers (40 ± 14.5) who were not exposed to the power looms were included in order to compare the outcomes.

Table 1. Demographic details of power loom workers

		Frequency	**Mean**	**SD**
N		51	-	-
Age	30-38	18	35	2.83
	39-44	18	41.5	1.4
	45-59	15	52	4.85
BMI	Healthy weight	21	22.2	1.55
	Obese	11	32.8	2.14
	Overweight	15	27.5	1.31
	Underweight	4	16.5	1.68
Gender	Male	12	-	-
	Female	39	-	-

2.2 Questionnaire Data

A questionnaire including socio demographic was prepared and survey made to the participants who were chosen by the Mini Mental State Examination (MMSE) scores, which consists of a set of 11 questions. It helps to check the cognitive impairment among the participants with their basic details which includes age, height, weight, location, experience in power loom etc., to identify the severity of exposure to the noise during their work experiences. With the considerations of MMSE scores, the participants with low scores were excluded to attain participants with the stable health conditions. The Stroop task was conducted with the help of a video formatted file with required timing to obtain better results from the test. This Stroop task provides response time by which the further analysis has to be processed.

2.3 Procedure

The computerized Stroop test is a well-known cognitive psychology experiment that enables scholars to study some aspects of attention, cognitive control, and speed of processing. It is conducted under 3 primary conditions; namely, Word Test, Color Test, and Color-Word Test (printed in the mother tongue, since most of the participants belonged to the Tamil Nadu state and have their mother tongue as Tamil).

2.3.1 Word Test

The words are printed in neutral ink (preferably black), to be read aloud or keyed-in as swiftly and as accurately as possible by the participants. In this Word Test, the measure of word-reading is compared with the speed of linguistic processing without the interference of color information. Because reading is an automated process for most literate individuals, most participants engage very quickly in the task where they are required to read words. They are presented on the screen in black color as shown in Figure 1. The participants have to read the word out loud and the corresponding time is recorded.

WORD (W)

மஞ்சள்	பச்சை	நீலம்	சிவப்பு
சிவப்பு	நீலம்	பச்சை	மஞ்சள்
பச்சை	மஞ்சள்	சிவப்பு	நீலம்
நீலம்	சிவப்பு	மஞ்சள்	பச்சை
சிவப்பு	பச்சை	நீலம்	மஞ்சள்

Fig. 1. Stroop Word Test

2.3.2 Color Test

In the Color test, subjects are presented with painted patches or blocks of colors (red, green, blue, and yellow). The task is to name the color of each patch very quickly and accurately. This test provides a baseline from which to assess his or her ability to identify and name colors with no linguistic interference, to measure speed of color recognition. Colored squares appear on the screen, which can be referred to as colors by the participants. For a fully computerized version, a typical set of colors is red, green, blue, and yellow is provided as shown in Figure 2.

COLOUR (C)

மஞ்சள்	பச்சை	நீலம்	சிவப்பு
சிவப்பு	நீலம்	பச்சை	மஞ்சள்
பச்சை	மஞ்சள்	சிவப்பு	நீலம்
நீலம்	சிவப்பு	மஞ்சள்	பச்சை
சிவப்பு	பச்சை	நீலம்	மஞ்சள்

Fig. 2. Stroop Color Test

2.3.2 Color – Word Test

The color - word test measures how participants name the color of words (“RED,” “BLUE,” and “GREEN”) with meaningfully incompatible ink colors as shown in Figure 3. The demands of the task require subjects to name the ink color rather than the word itself. This paves the way for the Stroop effect, owing to the brain’s great difficulty in choosing to ignore the word and simply concentrate on the color. These tests assess the extent of the subjects’ inhibition on the automatic reading urge to name the word instead of the ink color. It thus tests cognitive control, attention, and inhibition. The tests conducted among the power loom workers is shown in Figure 4.

COLOUR WORD (CW)

மஞ்சள்	பச்சை	நீலம்	சிவப்பு
சிவப்பு	நீலம்	பச்சை	மஞ்சள்
பச்சை	மஞ்சள்	சிவப்பு	நீலம்
நீலம்	சிவப்பு	மஞ்சள்	பச்சை
சிவப்பு	பச்சை	நீலம்	மஞ்சள்

Fig. 3. Stroop Color – Word Test

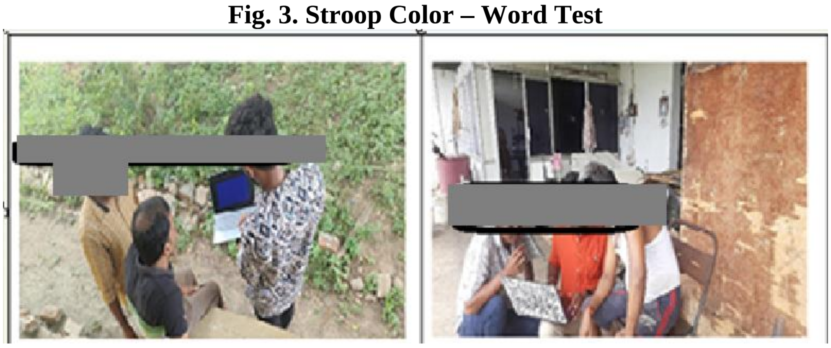

Fig. 4. Conduct of Stroop Test to the Power Loom Workers

2.4 ERP Acquisition

The EEG signals were recorded to analyse their brain signals before and during the performance of a task using EPOC X - 14 Channel EEG Headset. The ERP results can be acquired in Emotiv Builder software. During the Stroop task the participants were advised not to focus on other things beyond the task to have better score and EEG recording with high accuracy.

2.5 Statistical analysis

The statistical analysis was acquired with help of Statistical Package for the Social Sciences (SPSS) software using ANOVA with the conditions such as, predicted color word score, incongruous score and interference score. The error or unrecorded channels can be neglected to avoid the error interference in the final score.

3. Results

The distribution of interference scores suggests that the majority of participants performed well on the test (indicated through a mean interference score of -3.0), which can be interpreted as a moderately effective cognitive control and attention for overcoming incongruent stimuli. In contrast, while some participants possessed positive scores on the interference, this indicates difficulty in maintaining control over cognitive interference. There was thus much variability in the degree of interference manifested by subjects aged 30 to 60 years. Based on these findings, it can be summarized that while there is a wide variation in cognitive performance, neither BMI nor age can predict cognitive interference in the current data set. A considerable variability in interference scores from the Stroop test is revealed in the histogram, wherein the 51 participants were scored between -19 to 10. The mean of interference scores stands at -3.0, with a standard deviation of 4.95, explaining the inverse interference scores of most participants. This indicates that most participants performed better in the incongruent task (naming the ink color) than in the congruent task (reading the word), reflecting stronger cognitive control and attention in managing conflicting stimuli. Few, however showed a positive interference score, indicating their interference with the cognition process between the color of the ink and the word itself, pinpointing individual differences with regard to inhibitory control and cognitive processing. Table 2 provides the T-test comparisons of BMI for the participants.

Table 2 T-test comparisons of BMI for the participants

Sample 1	Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.
Underweight	Healthy weight	11.006	7.856	1.401	0.161	0.967
Underweight	Obese	13.67	8.408	1.626	0.104	0.624
Underweight	Overweight	20.892	8.104	2.578	0.01	0.06
Healthy weight	Obese	-2.665	5.36	-0.497	0.619	1
Healthy weight	Overweight	-9.886	4.868	-2.031	0.042	0.254
Obese	Overweight	-7.221	5.716	-1.263	0.206	1

The ANOVA results given in Table 3 for interference scores from the Stroop test show no trend of significance among the compared groups. F-ratio value of 0.616, with a p-value of 0.874, is an indicator that the variation among groups is approximately the same as the variation observed within groups. This implies that group membership did not significantly affect participants' scores of interferences, and any variability exposed in interference scores is more due to random variability than any real effect or influence from the tested conditions. Even BMI category-wise comparisons bring forth understanding against different weight classifications. To begin with, in the comparison of underweight to healthy weight, the test statistic is 11.006 with a significance value of 0.161. Thus, the two groups are not significant in contrast. Underweight to obese also engenders no significant differences, as it showed a significance level of 0.104. Nevertheless, when correlated underweight with overweight, a very low significance value of 0.010 is evident-a significant difference exists at the 0.05 level which becomes irrelevant at a Bonferroni correction adjustment of 0.060. In the comparison of healthy weight with obese, the insignificant p-value of 0.619 shows that there is no significant difference, whereas 0.042 indicates a difference is noticed when compared with overweight but becomes less important when adjusted (0.254). Obese versus overweight similarly fades as no significant difference, with a p-value of 0.206. To summarize, it is indicated that in several comparisons, although there exists significance, notably those containing underweight and overweight categories, many other comparisons show no significant results, thereby showcasing the complexities concerning BMI-related classifications and the inferences thereof with respect to health analysis. In addition, the ERP results show a pattern that the workers in the power loom generally show higher variability and more extreme peaks in the graph as shown in Figure 5, indicates their exposure towards the high noise exposure and stress level. Controlled people maintain more consistent patterns suggesting a baseline unaffected by high noise exposure. The F3, F4, FC5, FC6 are the frontal channels which majorly relate to the Stroop effect including the response inhibition and mental focus. The controlled people show relatively stable changes in the F3 region, indicating good attention levels and cognitive control. In contrast, the power loom people show much more fluctuation, which may indicate that the attention processes are irregular or disrupted.

Table 3. ANOVA table

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	811.078	38	21.344	.616	.874
Within Groups	415.667	12	34.639	-	-
Total	1226.745	50	-	-	-

Larger peaks and troughs of the power loom group could suggest higher sensitivity to stimuli but also less regulated or impulsive reactions. In the F4 region, both groups initially show similar patterns; however, the sharper responses in power loom people at the ERP suggest a heightened emotional or task-related response. This indicates an inability to sustain balanced attention over time and could be influenced by work stress or contextual factors impacting the way the brain is processing information. Their ERP responses show sharper spikes, indicative of over-activation when responding to stimuli. In the FC5 region, controlled individuals show far more stable attention, as the ERP signals are smoother and more regular.

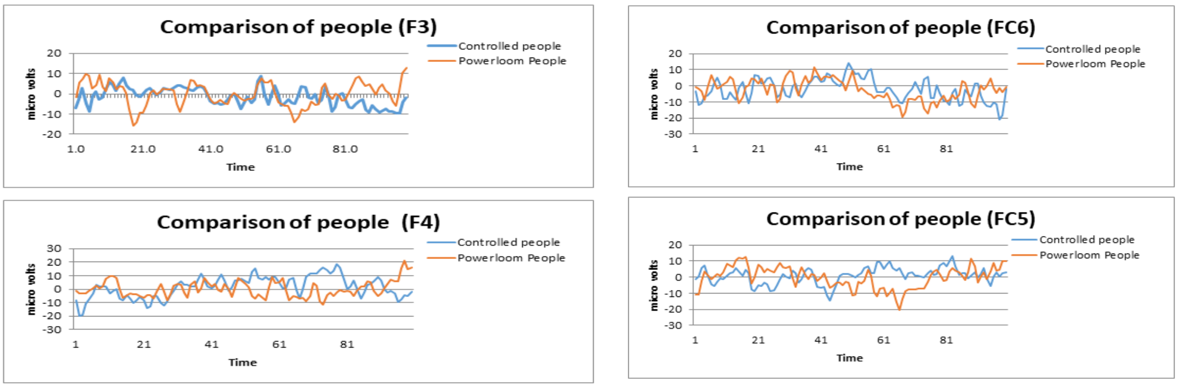

Fig. 5. Comparison of Power Loom Workers with Controlled People

In this respect, power loom people manifest deep negative troughs, which can be conceived as lapses in attention or an inability to maintain focus. The abrupt ERP voltage fluctuations of power loom people can be described as over responsiveness, possibly owing to sensory overstimulation or stress-induced reactivity. In the FC6 region, the two different groups show much closer profiles, indicating that the ongoing processes of attention in the area are less influenced by exogenous occupational factors. Power loom people produce slightly higher deviations, indicating the relatively heightened responsiveness to stimuli over controlled individuals. Thus, the ERP patterns for controlled individuals are stable and consistent across all regions, showing balanced attention and controlled reaction. This means that they function in an environment that is conducive to mental stability. In power loom workers, the ERP responses are more variable in individuals, particularly in the F3, F4, and FC5 locations. This could be a consequence of increased reactivity and disrupted attention processes. Factors at work that could likely bring about these changes include loudness, an intense workload, or unstable surroundings. Ups and downs seen in this suggest a predisposition toward overstimulation or an underdeveloped ability to sustain concentration and cognitive control.

4. Discussion

This study reveals that the outcome of the Stroop test performance has been collectively induces by both cognitive stressors and demographic factors. As documented from the earlier studies, the age factor played a vital role in decline of executive functioning, where the aged participants reaction time is slower and the interference scores are on the higher side [10-12]. The Stroop tasks highlights that elderly participants have different activation patters in the prefrontal region and decline in functional connectivity, which aligns with the former neuroimaging studies [15-17]. The education also has it impact on the Stroop test scores. The cognitive control is very low with the workers having poorer educational attainment. This result matches with the researches carried over different inhabitants, where the inadequate education deficits working memory, inhibitory control and cognitive flexibility [14, 18]. The outcome is widespread, due to minimal among the majority of power loom workers. The another major influencing factor of cognitive ability is the noise exposure. The prolonged occupational noise impacts the general mental health, working memory and attention [9, 19, 20]. The outcome of the research coincides that the noisy occupational environment acts a cognitive stressor. The noise induces physical and metabolic dysfunctions is clearly exhibited in previous researches [21-23]. Based on the gender differences very much lesser intrusion on the Stroop performance. While the earlier studies provide insights that some of the male participants have advantage over female participant's in specific Stroop tasks [24, 25], our results showcases that cognitive stressors have very minimal effect on the cognitive outcomes. Altogether the outcome of this study discloses the connectivity between demographic factors, occupational hazards and cognitive control. Also, the study implies on the necessity to take measures for noise reduction in workplaces, ergonomically designed workspace and cognitive training for this large population of power loom workers. These reforms will help them to overcome the impact of cognitive stressors, further will improve their physical and mental health.

5. Conclusion

This study reveals that the cognitive ability of the power loom workers has substantial deficit as measured by Stroop intervention scores. The worker's performance on the Stroop test and their inconsistency in interference scores, highlights prolonged exposure to cognitive stressors have extensive impression on the attention and executive performance. The sluggishness in reacting to the tasks and higher interference scores among minimal educated and elderly workers indicates the influence of limited cognitive reserve and cognitive aging. The research findings showcases that the executive control of this vulnerable population is impaired by the cognitive stressors and demographic factors. The future studies shall adopt neuroimaging and biomarker analysis to understand the impact of occupational surroundings to the mental health of the power loom workers. In sum, the study exposes that the cognitive performance is not an individual aspect but collectively environment, demographic and psychosocial factors also play their role in the occupational neuropsychological studies. The policies need to address these variables to enhance the cognitive health and productivity in this industrial setup.

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Authors' Contributions

All authors contributed equally to the study's conception, design, data collection, analysis, interpretation, and manuscript preparation. All authors read and approved the final manuscript.

Ethical Approval

Not Applicable

Consent to Participate

Informed consent was obtained from all individual participants included in the study.

Consent to Publish

Participants provided consent for findings to be published.

Competing Interests

The authors declare that they have no relevant financial or non-financial interests to disclose.

Data Availability Statement

The datasets generated and/or analysed during the current study are not publicly available due to the nature of the industrial research but are available from the corresponding author upon reasonable request.

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